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ELECTRIC EQUIPMENT AND RECONSTRUCTION OF THE NEW YORK TERMINAL LINES AND GRAND CENTRAL STATION, NEW YORK CENTRAL & HUDSON RIVER R. R.

During the past three years the New York Central & Hudson River R. R. Co. has been at work equipping its passenger terminal in New York City for electric traction. Under the stimulus of commercial and operating necessity and of a legislative act which required the company to undertake the removal of steam locomotives from the Park Avenue tunnel (a part of the railway's terminal approach in the City of New York), the work was taken up by the railway officers in a broad and comprehensive fashion, and has far exceeded the scope necessary to fulfill the law's requirements. In the form now being executed—and nearing completion—the terminal work embraces the following items:

I. Equipment of the company's principal passenger lines out of New York City for electric traction, to a distance sufficient to include the territory of heavy suburban or commutation travel. The electric installation under present plans is being carried as far as South Croton on the railway's main line, a distance of 34 miles, and to North White Plains on the Harlem Division, 24 miles out from the Grand Central Station, the New York terminal. In contrast to these wide limits of what the railway terms its Electric Zone, it is noted that the Park Avenue tunnel, two miles long, is wholly included within a distance of three miles from the Grand Central Station, and the railway's Mott Haven yards, the first point at which a change of motive power could practicably be made, is only five miles from the terminal.

II. Extensive enlargement of the terminal yard at Grand Central Station, and complete reconstruction of the terminal stubs and the station itself.

III. Laying additional tracks on the two divisions mentioned within the Electric Zone. The Hudson Division, which now has four tracks on a small part of its length, three tracks for most of the distance, and only two tracks at a few points, will be fitted with four tracks throughout the Electric Zone, with six tracks at many points, and at some places eight. The Harlem Division, which already has four tracks to Woodlawn (where the New York, New Haven & Hartford Ry. leaves the New York Central terminal tracks on its way to New Haven), will be four-tracked from this point out to North White Plains. These provisions will enable a complete separation in the Electric Zone of suburban (or local) and through traffic, by giving one local and one through track in either direction.

IV. Improvements in alinement and trackage at numerous points in the Electric Zone. The most important single piece of work is at Kingsbridge, at the upper end of Manhattan Island, New York City, where a large S-shaped curve is being straightened, eliminating three-quarters of a mile of distance and seven grade crossings. This change is known as the Marble Hill Cut-off. Rectification of alinement is also planned, or in progress, at many points along the Hudson River, the tracks being carried farther inland at some points, and at others across indentations of the river bank. Rather extensive work is also involved in track improvements on the short Port Morris spur, which runs from the main line at Mott Haven to tidewater at Port Morris, where lighterage and car-ferry terminals are located. At Mott Haven a new station will be built, second in importance only to the Grand Central Terminal. At the Mott Haven track junction, where two four-track lines unite in a single four-track trunk, all track-crossings will be eliminated. In connection with the track improvements it may be remarked that left-hand running, which has long been and is still being used between Grand Central Station and Spuyten Duyvil, will be abandoned in favor of universal right-hand running.

The work arranged roughly under these four heads is of great magnitude and of extreme importance and interest. It presents, in part, the complete solution of an old and difficult problem: the problem of bringing the New York Central's heavy passenger-traffic into the heart of New York City at once safely, expeditiously and without creating a public nuisance in the high-class residence quarter through which the line south of the Harlem River runs. In part, a new technical condition is presented: the operation of a large terminal division of a first-rank trunk line by electricity, with equal regard to a heavy through traffic at all hours of the day and a heavy suburban or commuter traffic concentrated in the morning and evening hours. This condition, in both its operating and its constructional aspect, is new in the transportation art. The case of the New York Central's Electric Zone exhibits *nearly all* of the important points of difficulty involved in complete electric operation of a large railway system, and this on a full-size scale.

A general description of the work is given in the following article, compiled from authoritative data and drawings. In way of preface we give a brief outline of the causes leading up to the work, and the stages through which the New York terminal problem has passed:

For many years past the passenger entrance of the New York Central & Hudson River R. R. into the city of New York has been substantially the same as it is at present: Leaving the east bank of the Hudson River (which is followed

VIEW OF NEW GRAND CENTRAL TERMINAL STATION OF NEW YORK CENTRAL & HUDSON RIVER R. R., NEW YORK CITY. MAIN OR FORTY-SECOND STREET FRONT.
(Halftone from Wash Drawing.)

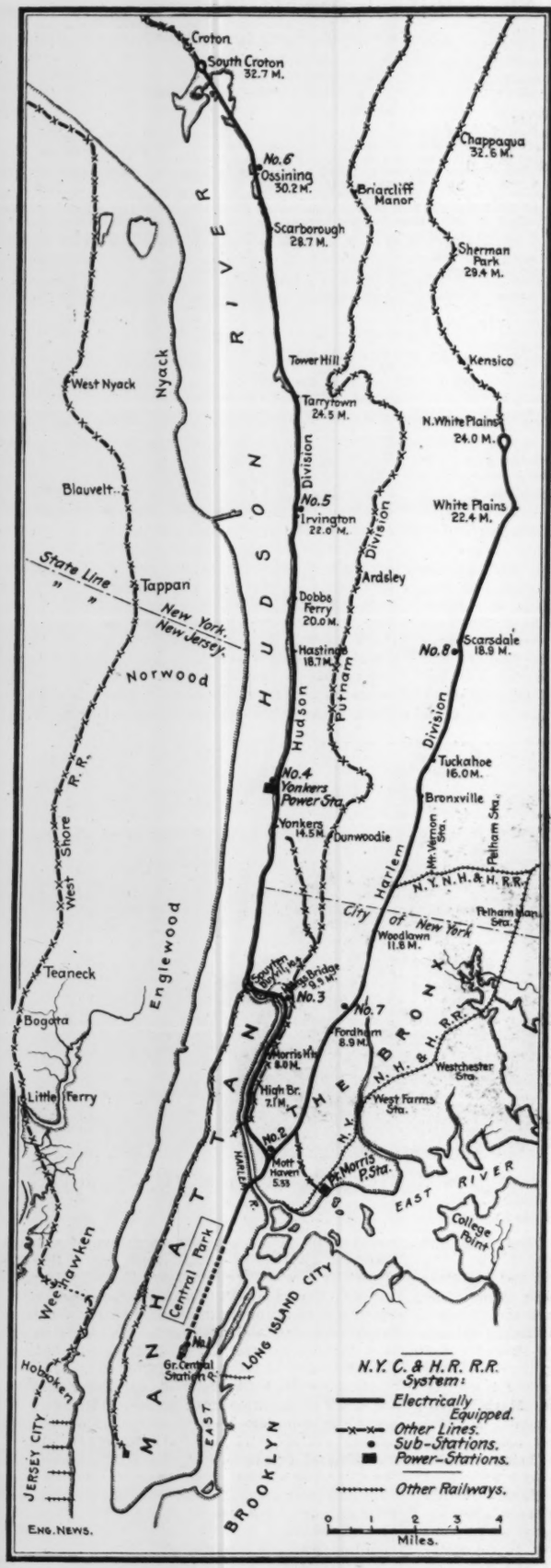


FIG. 1. MAP OF NEW YORK TERMINAL LINES AND ELECTRIC ZONE, NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

south 160 miles from Albany, N. Y.) at Spuyten Duyvil Creek, the northern boundary of Manhattan Island, the line describes a great sigmoid curve eastward and then runs southerly along the east bank of the Harlem River, generally under the lee of a high bluff, to a draw-bridge at 138th St., where it crosses onto Manhattan Island.

Up to about ten years ago this bridge was a low-level structure and had to be opened for every passing tug-boat and barge. The interruptions to the railway service became so great that it was replaced with a new structure at a sufficient height to pass ordinary tug boats and barges without opening the draw. At the same time, by joint action of the railway company and the city, the line from the Harlem River south to 99th St. was placed on an elevated structure. At 99th St. begins the well-known Park Ave. tunnel, which continues south for two miles to 56th St.; from this point to the Grand Central Station, at Park Ave. and 42d St., the tracks fan out into a small terminal yard.

A short distance northeast of the Harlem River crossing, at Mott Haven Station, in the Borough of the Bronx, New York City, a separate division of the New York Central, the Harlem Division, which extends north 127 miles to Chatham, N. Y., joins the main line for entrance into the Grand Central terminal. The Harlem division carries, besides its own suburban and through traffic, the entire passenger traffic of the New York, New Haven & Hartford Ry., which joins it at Woodlawn, 6½ miles north of Mott Haven. All this traffic debouches into the New York Central main line at Mott Haven for entrance into the Grand Central terminal.

There are two other New York Central lines entering New York City, but they are not concerned in the present improvements, nor do they greatly affect them. These are: (1) A branch leaving the main line at Spuyten Duyvil and running thence south along the east bank of the Hudson River to a freight terminal at 30th St. and Ninth Ave., from where a freight track extends south through Tenth Ave. and West St. to a freight depot at St. John's Park, in the lower New York wholesale district. (2) A passenger line, wholly distinct from other lines of the New York Central system, extending south about midway between the Hudson River and the Harlem Division, and crossing the Harlem River at 159th St., where it makes connection with the West Side elevated lines of the Manhattan Ry. (Interborough Rapid Transit Co.); this is known as the Putnam Division. While both these lines are of interest in a general consideration of the New York terminal problem, and have much local importance, they do not affect the work here to be described, and no further mention will be made of them.

The four-track line from Mott Haven to the Grand Central Station, as noted above, carries a traffic which is perhaps without parallel in the records of railway terminals. Two great trunk lines and an important branch line send all their through passenger traffic over it, and in the morning and evening "rush" hours all three lines add to this a very heavy suburban traffic. The daily movement over the line is at present about 1150 trains and light engines, which number includes 640 revenue trains, carrying 45,000 passengers. The line has for years been taxed to its utmost capacity. The throttling points on the line are the junction at Mott Haven, the Harlem River crossing, the terminal switching facilities at Grand Central Station and the Park Ave. tunnel.

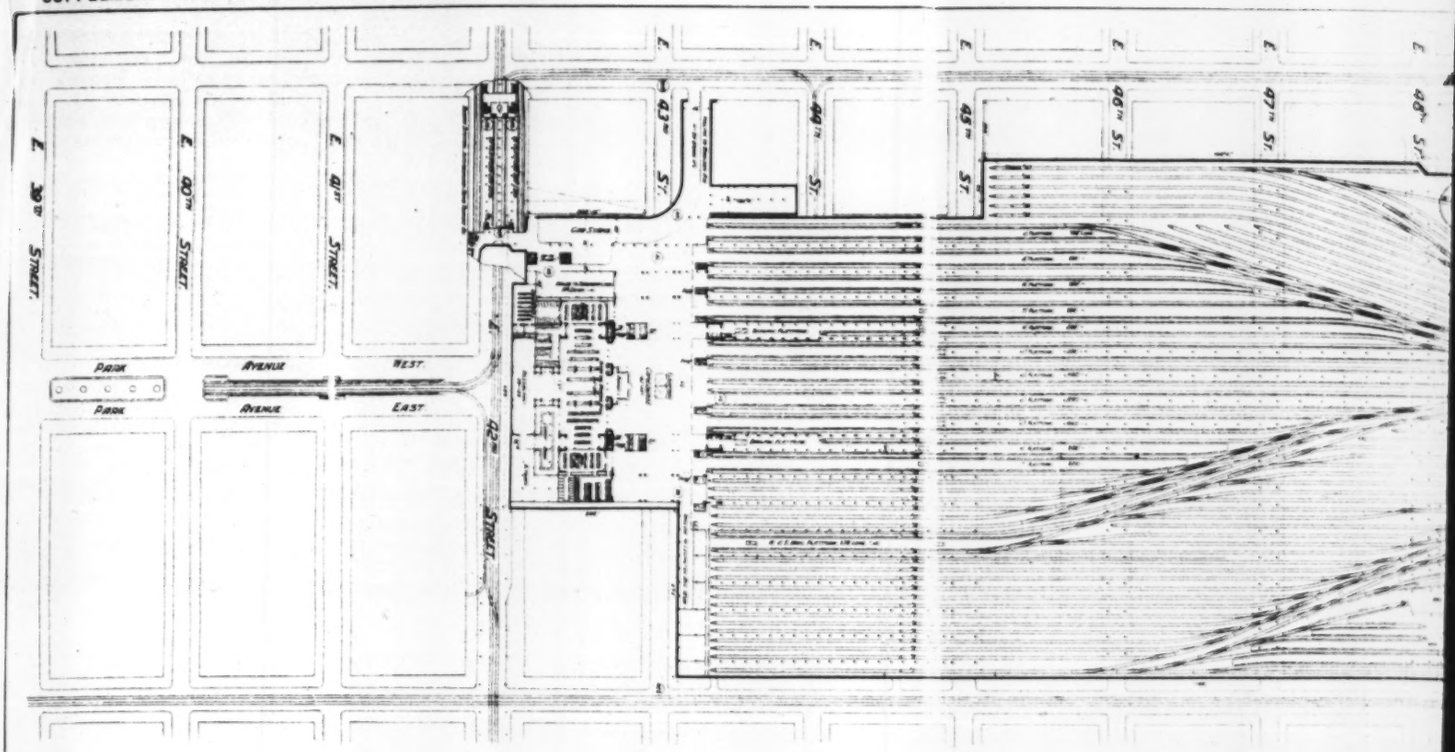
The latter has been by far the most serious, not only in limiting the traffic capacity, but also in making travel (in summer especially) excessively uncomfortable, because of the high temperature and the dense atmosphere of smoke and gases. The last-named conditions, by obscuring the light of signal lamps and therefore compelling slow running of trains, reduced the capacity of the tunnel in spite of one of the most intricate and complete signal systems in the world. These conditions were also directly responsible for two serious railway accidents, which occurred in the tunnel, one in 1891,* the other in 1902,† both rear collisions. The more recent of these accidents had much influence in starting the present improvements. It cannot be called their direct cause, however, because long before the collision there had been great public dissatisfaction with the condition of the Park Ave. tunnel, and much agitation for this or that form of improvement, as also frequent deliberation of the subject by the company's Board of Directors.

Previous to the accident of Jan. 8, 1902, several schemes for the improvement of the tunnel had been advanced, some by the railway company, others by outside parties, having in view the amelioration of either traffic conditions or sanitary conditions, or both. The plan most favored by the company was the partial conversion of the tunnel into open cut (see for example Engineering News of Oct. 17, 1901), but this was objected to by abutting property owners as it would make worse a condition which they already considered unbearable. A plan for forced ventilation, by fans and chimneys, had also been worked out, which plan was favored by the public as it involved covering the existing openings of the tunnels. This plan met with no sympathy on the part of the company, however, because any possible amelioration of the smoke nuisance would but partially cure a trouble which the company felt could be radically cured only by a very large increase in the terminal facilities at the Grand Central Station, combined with change of motive power from steam to electricity. As more fully noted below, the company had given serious consideration to electric traction as far back as 1899, and the accident of 1902 merely hastened the decision. The great amount of consideration given to the problem of this tunnel is reflected by the abundant references to it in the pages of Engineering News during the past five or six years.‡

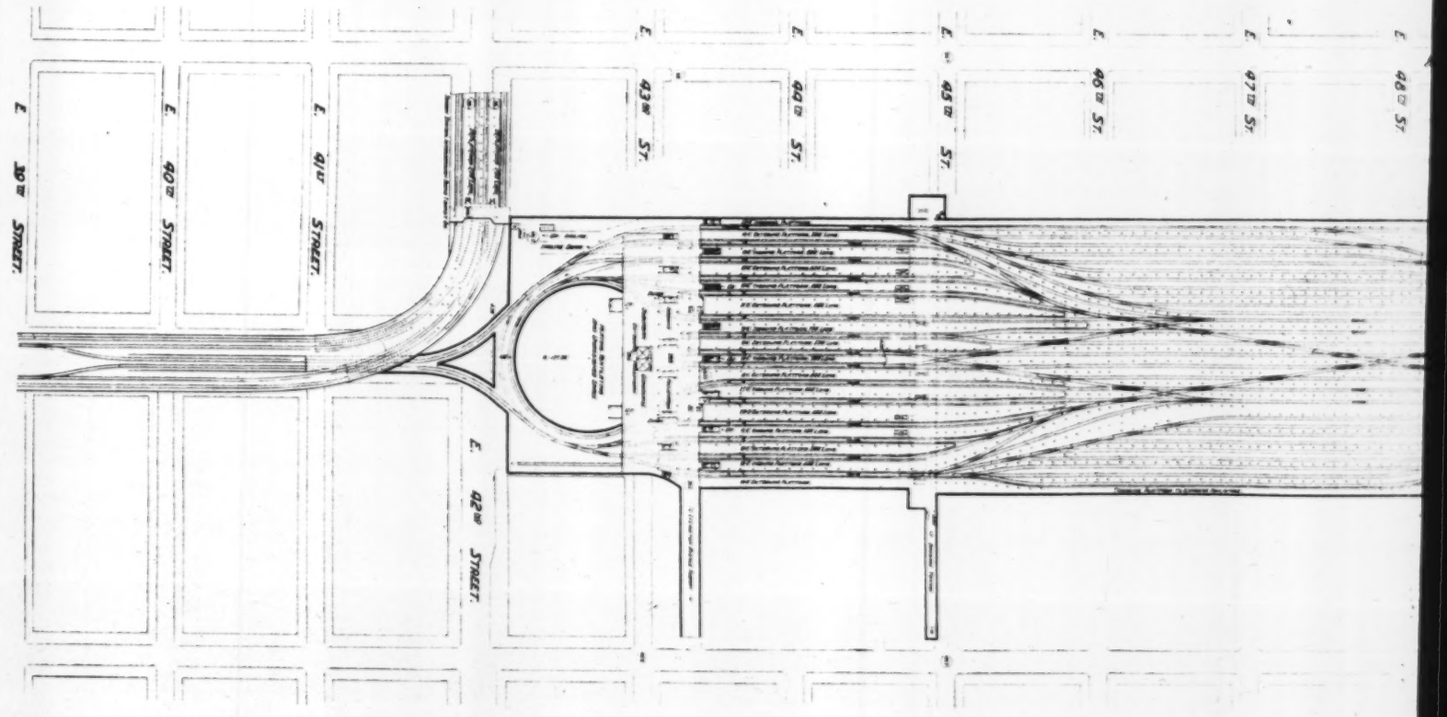
After the 1902 accident, the existing signal system in the tunnel (lamp, bell and torpedo) was improved by adding an equipment of Miller signals,§ which makes the engineman independent of the visibility of fixed signals by lighting red or white lamps in the engine cab. This system, with its track circuits superimposed on the existing ones, has been in operation since then. The speed of trains while traversing the tunnel was reduced, and the blocks were lengthened to a minimum of ½ mile. These expedients, contributing variously to safety and rapidity of train movement, had no effect on the bad condition of the air in the tunnel.

Meanwhile it had become more and more evident that no insuperable difficulties lay in the way of electric operation of the terminal line,

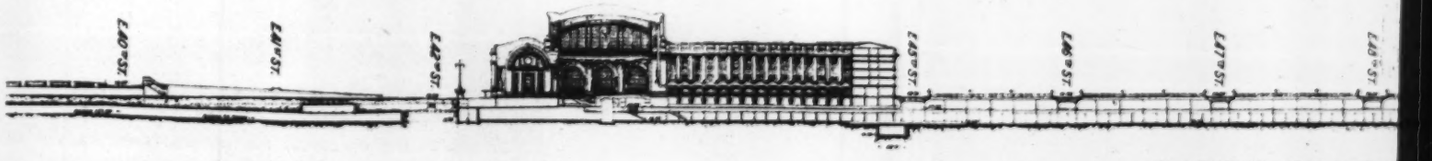
*Eng. News, Feb. 28, March 7, April 4, 1901.
†Eng. News, Jan. 9, 1902, and following issues.
‡See especially Eng. News, 1901, I, pp. 17, 130; 1901, II, pp. 24, 88, 95, 290, 408; 1902, I, pp. 67, 68, 77, 130, 274; 1902, II, p. 83.
§Eng. News, 1902, II, 527.



PLAN OF UPPER TRAC



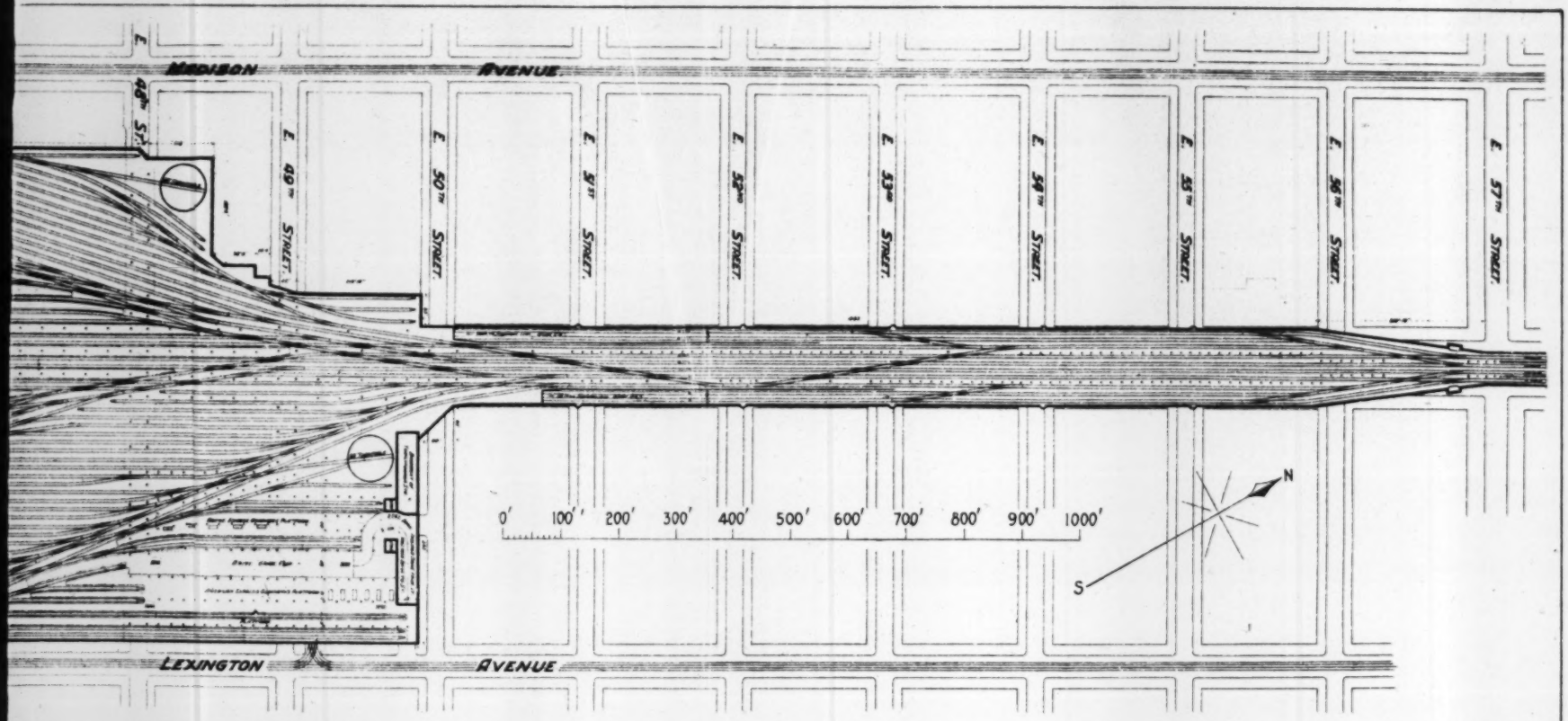
PLAN OF LOWER TRACK LEVEL (SUBURBAN LEVEL). SH



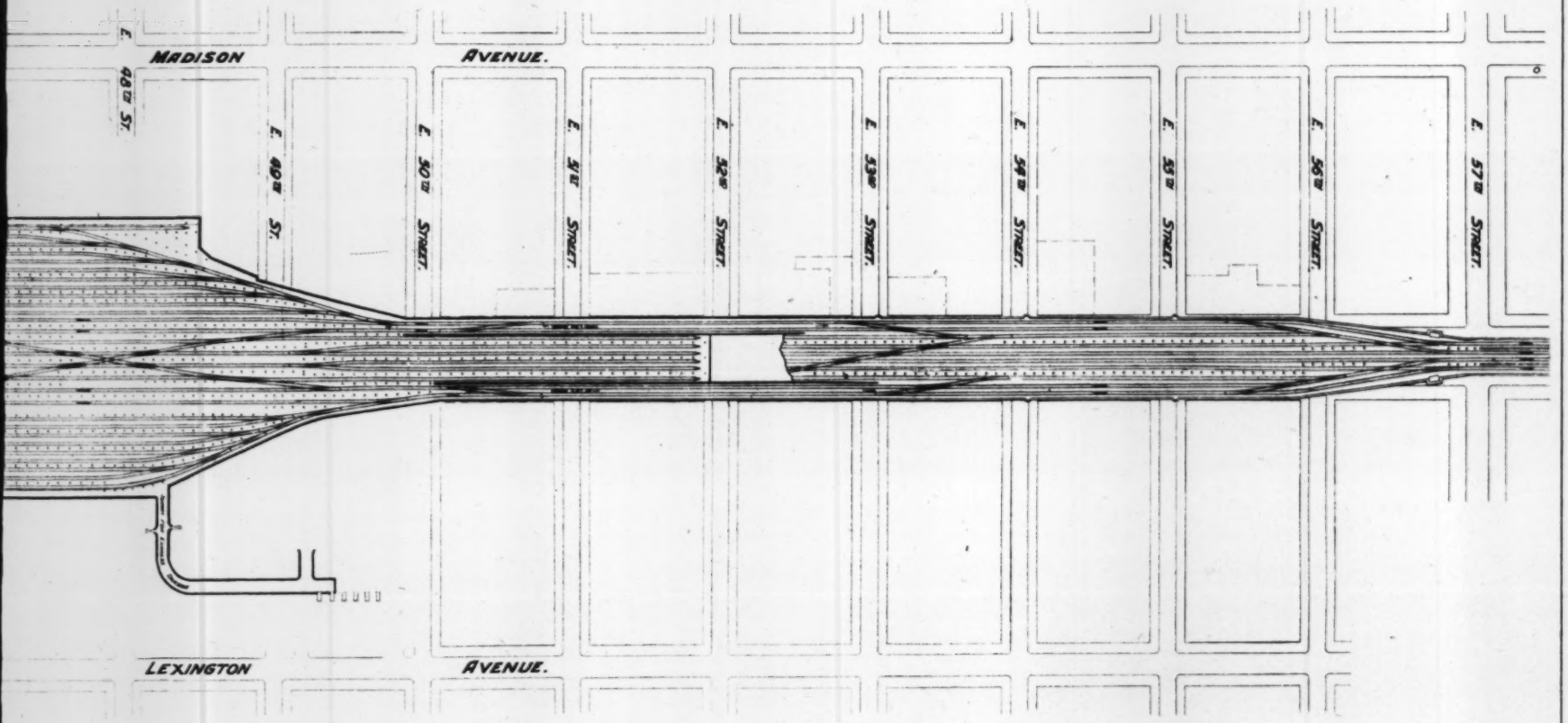
LONGITUDINAL SECTION THR

GRAND CENTRAL STATION AND ADJACENT TERMINAL

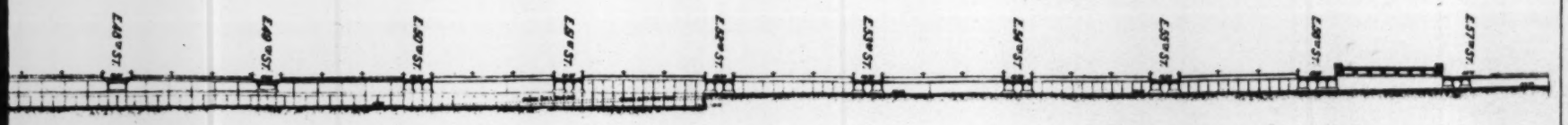
New York Central & Hudson River R.R. Co.



OF UPPER TRACK LEVEL (MAIN LEVEL).



RBAN LEVEL), SHOWING CONNECTION TO NEW YORK RAPID TRANSIT SUBWAY



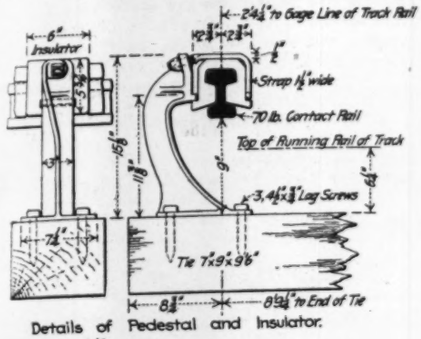
L SECTION THROUGH STATION AND APPROACHES.

ERMINAL YARD, NEW YORK CITY, AS NOW BEING RECONSTRUCTED.

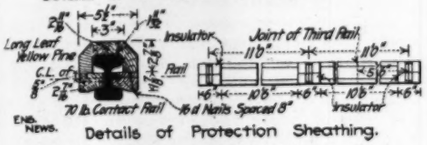
W. J. Wilgus, M. Am. Soc. C. E., Vice-President in charge of construction.

CHAS. HART, LITH., 34 VESEY STREET, NEW YORK.

which would keep the steam locomotive out of the tunnel and thus solve the major difficulty. The successful use of large-capacity electric locomotives by the Baltimore & Ohio Ry. in its Baltimore terminal tunnel, and the electric oper-



Details of Pedestal and Insulator.



Details of Protection Sheathing.

ation of elevated railways in Boston, Chicago and New York, without going farther afield, gave abundant demonstration of the possibility of electric working. The far greater complication of the problem in the present case still left many questions to be resolved, of course, and as to financial results under electric terminal operation there was no certainty whatever; but the mere question of engineering practicability, it appeared, required no further demonstration.

Even before the Park Ave. tunnel accident of 1902, and long before the electric terminal equipment here to be described had been decided upon, the railway company had, in August, 1901, commissioned Mr. B. J. Arnold to make a study of traffic between Grand Central Station and Mott Haven, with a view to determining the feasibility of electric operation over this line. The resulting study (abstracted at length in Engineering News of July 31, 1902, p. 88) included an extensive experimental investigation of the power required by trains of various kinds running over this line, and prouuced conclusions as to the total power equipment necessary, the most suitable type of power supply, and the cost of installation and operation.

An organization of the property-owners adjacent to the Park Ave. tunnel in 1901, was active in agitation for legislation to compel the use of electric trains in the tunnel. The serious accident of Jan. 8, 1902 had a large influence in inducing action by the public officials which finally took the form of a legislative act compelling a change to electric motive power to be made by the year 1908.

In the discussions which preceded this legislative action, the city authorities came to an understanding with the railway company that the city would not oppose such extension of the Grand Central terminal yard as might be found necessary for satisfactory operation of the electric system. This agreement, or rather the yard extension which it facilitated, is of much importance to the improvements here in question. The cramped track facilities at the terminal were in no small degree contributory to the bad traffic conditions in the tunnel, partly by interfering with freedom to arrange trains in a way to utilize the tunnel fully at all hours, and partly by compelling a great amount of empty train movement between the terminal and the Mott Haven storage yards. Moreover, it was impossible, for lack of capacity, to adequately accommodate (not to say develop) the suburban traffic of any of the three lines entering the terminal, which condition gave rise to chronic dissatisfaction on the part of the commuters and (probably) to considerable loss of revenue on the part of the two railway companies. With the terminal enlargement, however, an adequate proportioning of trackage to traffic became possible. As the table farther on exhibits, the new terminal, as compared with the old, shows an increase in ground area of 178%, in track length of 151%, and correspondingly in other facilities.

The determinative factors above outlined led quite naturally to the development, in close interrelation, of the several main features of the terminal and electric traction improvements described farther on. Thus, the use of electric motive power once fixed, the needs of the traffic virtually dictate the adoption of heavy electric locomotives for through trains, to be exchanged for steam locomotives at some convenient division terminal. For through traffic this interchange gives rise to no great inconvenience. Suburban traffic, on the contrary, should preferably not be subjected to this delay, and as electric power must be used at the New York end, it should preferably be used throughout the zone of suburban travel. But when complete electric operation of suburban trains is possible, the value of high acceleration and high net load ratio as obtainable by multiple-unit operation claims attention. Also, since with adequate terminal trackage it is possible to make a complete separation of local from through traffic, the two kinds of traffic may be handled as separate problems, aside from current supply; there is then no incongruity in using electric locomotives for through traffic and multiple-unit trains for suburban. With suitable track and way-station changes the physical separation of the two kinds of traffic may be carried throughout the zone of electric operation, and the operating advantages of separated traffic may be realized to their full extent. Of the main features of the work only a single one, the nature of the electrical supply, is unaffected by the precedent conditions.

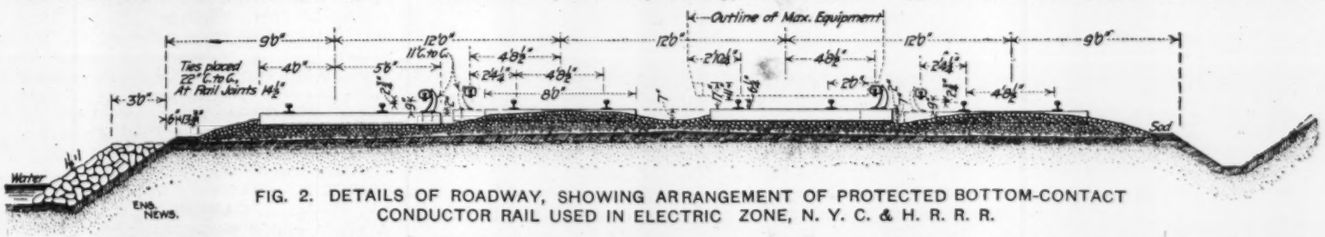


FIG. 2. DETAILS OF ROADWAY, SHOWING ARRANGEMENT OF PROTECTED BOTTOM-CONTACT CONDUCTOR RAIL USED IN ELECTRIC ZONE, N. Y. C. & H. R. R. R.

ORGANIZATION.

The conduct of the large group of undertakings embraced by the improvements thus initiated required a large and specialized organization for planning, designing and constructing. The existing engineering organization of the New York Central & Hudson River R. R. Co. was at once appreciated to be inadequate for the task. The first step taken to meet the new problems was the appointment of an Electric Traction Commission, working under Mr. W. J. Wilgus, M. Am. Soc. C. E., Vice-President and engineering head of the New York Central & Hudson River Ry. This commission consists of Messrs. B. J. Arnold, M. Am. Inst. E. E., of Chicago, Ill.; Frank J. Sprague, M. Am. Inst. E. E., of New York, and Mr. J. F. Deems, Genl. Supt. Motive Power & Rolling Stock, N. Y. C. & H. R. R., together with Mr. Wilgus. At first this commission, with the addition of Mr. E. B. Katte as Electrical Engineer, was the only new element, working alongside the regular organization under charge of Mr. H. Fernstrom, Chief Engineer. Gradual develop-

Track Side of Conductor Rail.

Rear Side of Conductor Rail.

FIG. 3. TWO VIEWS OF TRACK WITH BOTTOM-CONTACT CONDUCTOR RAIL.

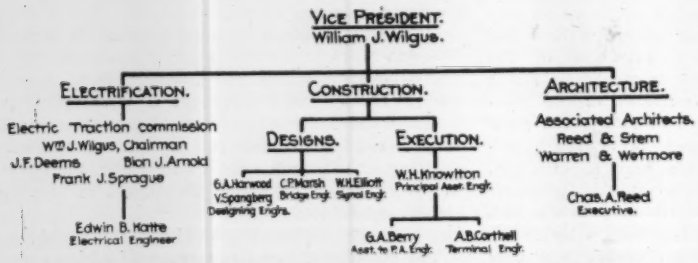
ment since that time, however, has produced a new and quite specialized organization.

For engineering purposes the entire railway system is divided into (1) the Electric Zone, and (2) the Exterior Zone. Each is headed by a Principal Assistant Engineer, reporting directly to the Vice-President. The organization of the Electric Zone, which is of interest at present, is exhibited

in the diagram given just below. It represents the exclusively Electric Zone staff, and does not include a number of engineering officials who report to the Vice-President directly, and may have connection with work in either zone or both.

Description of Terminal and Electric Work.

A map of the region over which the New York Central & Hudson River R. R. Co.'s terminal improvements extend is shown in Fig. 1, in which heavy full lines have been used to indicate the



SCHEME OF ENGINEERING ORGANIZATION, ELECTRIC ZONE, N. Y. C. & H. R. R. R.

divisions over which the electric operation is being installed, while other New York Central divisions are shown by heavy broken lines. Croton-on-Hudson, on the main line or Hudson Division, and North White Plains, on the Harlem Division, are the terminal points of the Electric Zone. Each division is four-tracked to these points, with two suburban tracks on the outside and two through tracks in the middle. On each division the suburban tracks are connected by a loop at the northern terminus. All tracks are equipped with third-rail, located outside of the track. Electric current is supplied to the Electric Zone from two generating stations, one located at Port Morris, Borough of the Bronx, New York City; the other at Yonkers, N. Y., on the Hudson River. Both stations are on tidewater and can thus receive coal both by water and by rail. At these stations three-phase current, at 11,000 volts pressure, is generated. The current is distributed by independent three-phase transmission lines to eight substations, located along the divisions served. At the substations it is transformed to low voltage and converted into direct current at 660 volts' pressure, which is the pressure supplied to the conductor rail. The running rails serve as return conductors.

ROADWAY AND TRACKAGE.

The arrangement of tracks and conductor rails is exhibited in Fig. 2, a cross section through the standard four-track roadway. The feature of prime interest is the conductor rail, an underrunning protected third-rail. The conductor rail is a bullhead rail, 70 lbs. per yd., supported at intervals of 11 ft. by cast-iron gooseneck pedestals, which are fastened each by three ¾-in. lagscrews to a long track tie. A two-piece porcelain insulator block, molded so as to completely surround the upper head and the web of the rail, is clamped in the pedestal and supports the rail. These insulators are 6 ins. long, projecting 1½ ins. on either side of the pedestal, which is 3 ins. wide; a forged strap, fitting over the block, holds it in place in the pedestal. Between insulators the rail is surrounded by a built-up wooden sheathing, whose cross section is similar to that of the insulator. Thus the live rail is protected along its entire length, leaving only the lower head of the rail projecting from the insulating sheath. Protection against interruption of service by sleet, ice and snow has been aimed at in this design, as well as protection to persons.

The lower or contact surface of the conductor rail is, as noted in the drawing, everywhere 2¾ ins. above top of track rail; laterally, the center of conductor rail is 2 ft. 4¼ ins. outside of the gage line, to the right in the case of the through tracks, to the left on suburban tracks.

At some special locations it is planned to use an overhead conductor in place of the third-rail. In approaching such sections an automatic device on the motor-car or locomotive will depress the contact shoes away from the third-rail and will lift the overhead contact arm into place.

The trackwork and third-rail installation is being done by the company forces.

The changes in trackage and structures include, beside complete four-tracking in the Electric Zone and installation of conductor-rail, many improvements in alinement, the construction of interchange yards and repair shops at the terminals of the Electric Zone, the elimination of grade crossings at many points, the reconstruction of way stations in the Electric Zone, and the rebuilding of the Grand Central Station and terminal.

Of the improvements in alinement, the most noteworthy is the Marble Hill Cut-off, at the northern end of Manhattan Island (indicated in the map, Fig. 1). Two curves are reduced at this point. The large northward curve around the bend of Spuyten Duyvil Creek, rendered unnecessary by the Government Harlem Ship Canal cut, is cut off by a flat curve supported on an embankment retained by cribbing on the Ship Canal side. The small southward curve, which rounds the point of a rocky bluff, is to be cut off by a rock tunnel, four tracks lined with concrete. This tunnel, 661 ft. l[illegible] will so far as we now recall be the first four[illegible]k single-arch tunnel ever constructed. It has yet been begun, as it is only a minor p[illegible] of the Marble Hill rectification and can be built and put into service at any time without interfering with traffic. The character of the tunnel construction, as designed, is indicated in the accompanying drawing, Fig. 6. D. D. Streeter is contractor for the Marble Hill work.

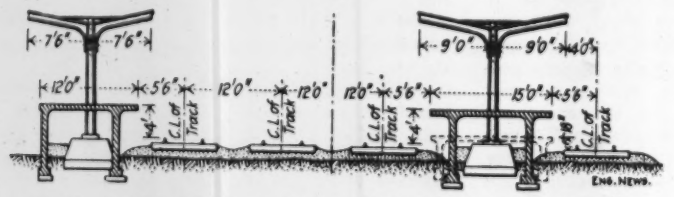
At Croton-on-Hudson and North White Plains, the northern terminals of the Electric Zone, facilities will be provided for the change from steam to electric locomotives, and vice versa, for through trains, and suitable shops erected for necessary repairs to the electric equipment.

It is planned to instal a complete new system of automatic signals in the Electric Zone, together with a comprehensive system of interlocking.

The frequent train service contemplated with the commencement of electrical operation renders it absolutely essential for the safety of the public, and the efficient movement of the traffic, that all grade street crossings within the limits of the Electric Zone be abolished. This will be accomplished at some points by means of overhead bridges; at others by carrying the streets under the elevated tracks. Such improvements will be made at High Bridge, Morris Heights, University Heights, Yonkers, Hastings, Irvington, Tarrytown, Ossining and other points on the Hudson Division; and at Woodlawn Junction, Mount Vernon, White Plains and other crossings on the Harlem Division; also at grade street crossings between Westchester Ave. and Long Island Sound on the line of the Port Morris branch. The extensive Mott Haven yard and station improvement, also belongs in this class.

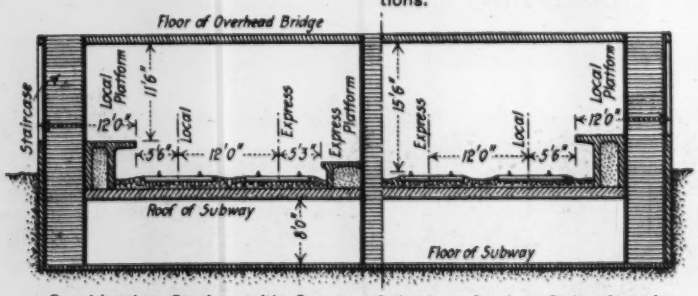
SUBURBAN STATION PLATFORMS AND CANOPIES.

A very essential phase of the plans developed for construction and traffic operation in the Electric Zone is the large attention given to suburban traffic. This is most strikingly typified by the adoption of "high" platforms, i. e., station platforms flush with car platforms, for the suburban sides of the way stations. The greater ease



High Outside Platforms for Purely Suburban Stations.

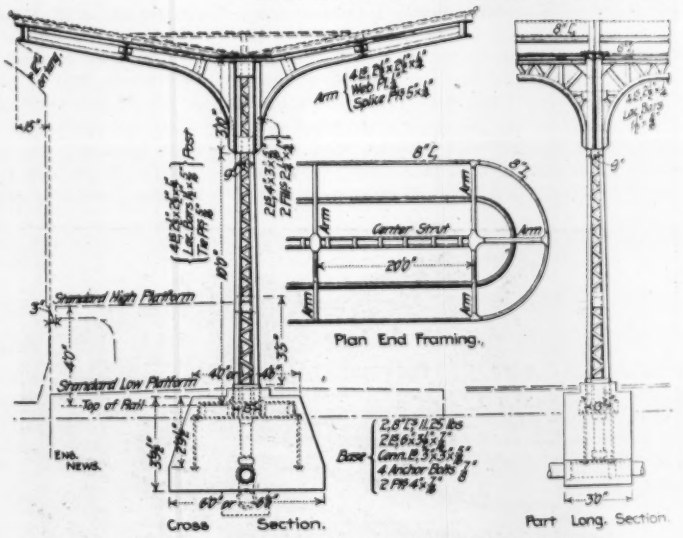
High and Low Island Platform for Combination Stations.



Combination Station with Separated Suburban and Through Platforms.

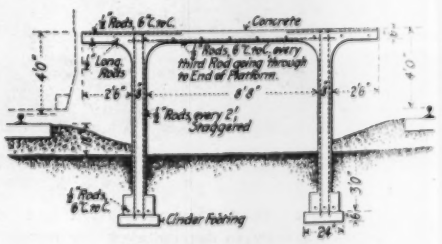
Suburban Station Only, Showing Arrangement of Bridge, Subway and Stairs.

SOME TYPES OF PLATFORM ARRANGEMENTS.



FRAMING OF STANDARD BUTTERFLY CANOPY.

FIG. 4. TYPICAL SKETCHES OF NEW SUBURBAN STATIONS, ELECTRIC ZONE, N. Y. C. & H. R. R. R., SHOWING HIGH PLATFORMS AND BUTTERFLY CANOPIES.



Section of Standard High Island Platform.

All exposed edges of concrete rounded to 1-in. radius. Concrete Class B (¾-in. stone) 1:3:6, with exposed surfaces faced with ½-in. cement finish, 1:1. Expansion joints every 25 to 40 ft., as may be directed by engineer. All reinforcing rods are round.

and rapidity of traffic interchange with this arrangement speak strongly for its use in service of this kind, where it is important to make stops of minimum duration in order to develop full traffic capacity. The decision to use high suburban platforms, together with the necessity of providing for the traffic of four tracks in varying manner at different stations, led to the formulation of completely new designs for station platforms and canopies on a harmonized basis. In Fig. 4 are grouped some illustrations which may serve as specimens of the resulting designs. Fig. 5, a view of the station at University Heights, exemplifies the architectural treatment.

FIG. 5. VIEW OF NEW STATION BUILDING FOR AN OVERHEAD STATION OF N. Y. C. & H. R. R. R., AT UNIVERSITY HEIGHTS, NEW YORK CITY.
(Halftone from Wash Drawing.)

Structurally, the type of platform adopted is a reinforced concrete construction, comprising two longitudinal 8-in. walls and a 6-in. deck or floor plate, which spans between the walls and overhangs 2 ft. 6 ins. on either side. The platforms vary in width from 12 ft. to 15 ft. normally; in some special cases they are wider than 15 ft. They are roofed over by "umbrella" or "butterfly" canopies, consisting of an independent tar-and-gravel wooden roof for each platform, carried on single-post bents, connected by a deeply-bracketed central strut and the requisite purlins. The roof framing is riveted steel work. The roof pitches inward from the edges to a central gutter, drained by conductors located in the interior of the four-angle latticed posts. The eave in all cases has an overhang of 18 ins. beyond the edge of the high platform (15 ins. for low platform).

The standard "high" platform has its floor 4 ft. above top of rail; the standard "low" platform is 18 ins. above *base* of rail (the level of platform edge being taken in both cases; the slope of floor is generally 1-16-in. per ft.).

The arrangement of platforms, in ground plan, varies greatly for different stations. The pure "suburban" arrangement employs a high platform, of 350 ft. minimum length, on either side, outside the group of four tracks. The typical "combination" station has either two outside high platforms and a central low island platform between the through tracks, or two island platforms between suburban and through tracks on either side, which are high at one end for a distance of 350 ft. and low over the remaining length, not exceeding 1,000 ft.

The location and spacing of all "high" platforms is such as to give a clearance of 3½ ins. (on tangent) between edge of platform and the clearance diagram of the electrical equipment (11 ft. wide for a height of 4 ft. 2 ins. above top of rail). On curves the corresponding clearance for inside middle and outside corners is 4½ ins., which gives the inside corners a clearance of about 12 ins. on a 5° curve. The tilting effect of superelevation is allowed for in addition, in determining the relative location of tracks and platforms. On curves all heights are measured from top of inner rail, which applies also to the 4-ft. height of platforms.

Stations will generally be provided with either overhead bridges or subways, or both, to connect the several platforms. With electric operation it is, of course, even more desirable than with steam that all necessity for crossing tracks at grade be avoided. The standard plans provide for stairways 5 to 15 ft. wide, with 5¼-in. risers, 13-in. tread, and 1½-in. nose. The station buildings will usually be overhead.

GRAND CENTRAL STATION AND TERMINAL.

The plans developed for the new Grand Central terminal have three salient characteristics: 1. A great increase of size, enabling all the facilities essential to a terminal to be much enlarged; 2. The provision of two tiers of tracks in the station and yard, one tier for through trains and the other for suburban trains; 3. The use of terminal loop tracks on the suburban tier, to facilitate loading and unloading and to reduce the terminal wait of the trains.

As brought out earlier in this article, the enlargement of the terminal is a vital, not to say central feature of the entire group of improvements in question. It will make possible an ample service, rapid, easily arranged to suit traffic conditions and free from congestion of tracks, hence an economical service. A large tributary suburban population exists along the lines entering the terminal, and there is every reason to suppose that with the improved facilities for handling the suburban traffic rapidly and comfortably, it will experience a great development.

The extent of the enlargement of the terminal and station is best exhibited in the subjoined statistical table:

COMPARATIVE STATISTICS, GRAND CENTRAL TERMINAL YARD AND STATION.

Subject.		Present.	As Reconstructed — Suburban Level.	As Reconstructed — Express Level.	As Reconstructed — Street Level and Above.	As Reconstructed — Total.	Increase Per Cent.
Area of Terminal, acres		23.24	24.22	40.32	.....	64.54	178
Track Mileage:							
Tracks—Platform	19 tracks	2.61	(15) 2.07	(20) 3.70	.....	(35) 5.77	98
Storage		1.54	2.94	5.57	.....	8.51	453
Express		.35	.....	.86	.....	.86	146
Mail		.16	.....	.20	.....	.20	25
Running and misc.		5.88	5.58	6.25	.....	11.83	101
Total		10.84	10.59	16.58	.....	27.17	151
Car Capacity:*							
Tracks—Platform		214	177	273	.....	450	110
Storage		640†	249	394	.....	643	0.51
Express		24	.....	61	.....	61	135
U. S. Mail		11	.....	15	.....	15	36
Total		891†	426	743	.....	1,169	31
Building ground floor, acres		5.90	.....	.....	8.10	8.10	37
Offices, sq. ft.		129,500	.....	.....	426,634	426,634	229
Post office, sq. ft.		33,000	.....	.....	104,577	104,577	217
Waiting rooms, sq. ft.		12,443	.....	24,637	.....	24,637	98
Retiring and toilet rooms sq. ft.		1,391	.....	9,080	.....	9,080	553
Restaurant and accessories, sq. ft.		2,647	.....	16,454	.....	16,454	522
Ticket offices, sq. ft.		1,444	.....	2,295	.....	2,295	58
Parcel stand, sq. ft.		507	.....	1,320	.....	1,320	161
Baggage rooms, sq. ft.		33,315	.....	60,800	.....	62,940	88
Concourses, sq. ft.		14,814	53,750	67,200	.....	120,950	717
Ticket lobby sq. ft.		1,490	.....	.....	18,298	18,298	1,128
Cab stands, sq. ft.		2,952	.....	11,535	28,105	39,640	1,243

* Car capacity computed on basis of 60-ft. cars on suburban tier, and 70-ft. cars on through tier.
† These two items include a car capacity of 525 at Mott Haven yards. All other figures in this column relate to Grand Central Station only.
‡ For Grand Central Station alone, increase in cars is 528, or 459%.

The general arrangement of the terminal is indicated in the drawings on the inset supplement sheet of this issue. The main (or "express") level, at the top of the sheet, is the upper of the two tiers of tracks. The suburban tier, below, connects with the tunnel tracks by two two-track inclines, one on either side of the through-track trunk, between 50th and 53d Sts.;

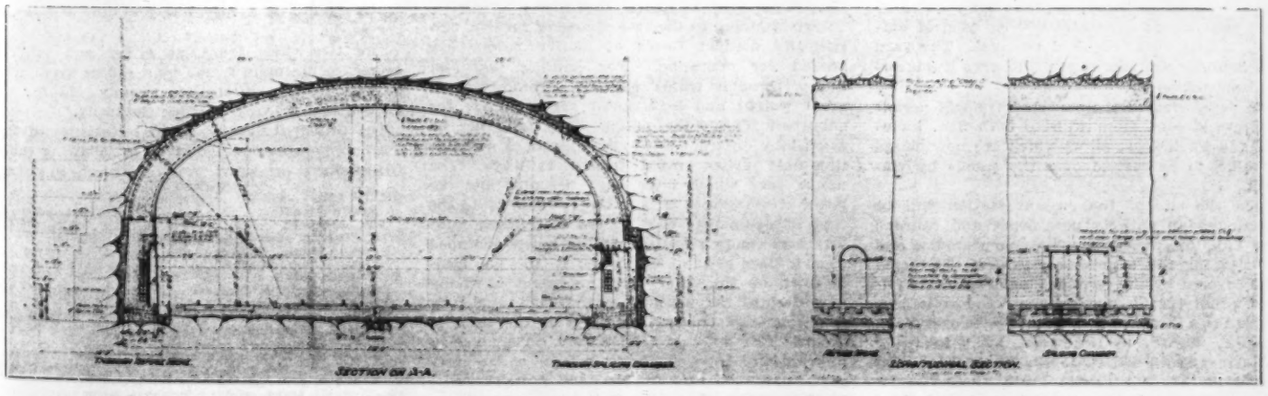


FIG. 6. FOUR-TRACK ROCK TUNNEL IN MARBLE HILL CUT-OFF, NEAR SPUYTEN DUYVIL, N. Y. C. & H. R. R. R.

these inclines have a grade of 2.16%. At the south or 42d St. end of the suburban level, the four easterly and the four westerly tracks are joined by a double-track loop, whose radius is 137¼ ft. on center line. Operation of long trains on such sharp curvature will be possible only because of the use of multiple unit trains, with their high starting pull. Turnouts from the loop track, shown in the drawing, lead into a two-track junction tunnel which connects with the New York Rapid Transit Subway. While it is not certain at the present time that this junction will be constructed at once, or that it will ever be built, it has been provided for in the designs. An entrance for passengers into the subway is arranged on the upper or express level, which communicates directly with the interchange bridge in the subway at its 42d St. or "Grand Central" station. As most of the suburban passengers of the terminal use the Subway in proceeding to or from the station, some such means of communication is a necessary convenience.

The new terminal covers, in addition to the space of the old terminal, about 20 acres of ground which was purchased by the company during the past four or five years. The buildings on this ground, residences, stores, apartment houses, churches and hospitals, to the number of nearly 200, have been removed, and excavation for the new terminal has been in progress since August, 1903. The work is necessarily slow, because the full amount of train movement must continue during the reconstruction. The new suburban yard is to be 35 ft. below the level of the present yard, and the main yard, which extends over the added territory, requires some 15 to 20 ft. of excavation; over 2,000,000 cu. yds. of material, largely rock, required removal. The yard work is under contract to the O'Rourke Engineering Construction Co.

The depression of the surface yard will permit the cross streets, from 45th to 56th Sts., inclusive, and Park Ave., all of which are now closed to traffic, to be carried over the tracks by viaducts.

Upon the site of the present station will be constructed an entirely new depot and railroad office building, including a branch postoffice and facilities for the express companies. The area to be covered by the terminal buildings is as follows: From 42d St. north along Vanderbilt Ave. to 45th St., a distance of 680 ft.; thence east along 45th St., 625 ft., to Lexington Ave.; following that street south 460 ft. to 43d St.; thence west on 43d St. 275 ft.; thence south along Depew Place to 42d St., and west 300 ft. to the place of beginning. The buildings will be set back 40 ft. from Forty-second St. and 70 ft. from Vanderbilt Ave., which with the street gives 140 ft. of open space on 42d St. and 130 ft. on Vanderbilt Ave. The main entrance will be on 42d St., with side entrances and exits on Lexington Ave. and Depew Place. The central architectural feature of the main entrance will be three arches, each 33 ft. wide and 60 ft. high. Beyond will be the ticket office space, 90x300 ft. On the street level, adjoining the ticket office on the right, will be the outgoing baggage-room, the contiguity of these two features being exceptionally convenient for the traveller. Adjoining is the gallery, overlooking the grand concourse, which will be on the level of the express tracks and will be reached from the gallery by four stairways, each 25 ft. wide. The concourse itself will be the largest in the world, being 160 ft. by 470 ft. and 150 ft. high, with wide entrances at each end from Madison and Lexington Aves. respectively. Adjoining the concourse will be the waiting rooms, telegraph offices, cafes, etc.

Separate entrances will be provided for the suburban passengers, with ample facilities for easily passing from one level to the other by means of broad stairways. The suburban station will be provided with its own concourse, commodious waiting and retiring rooms, and other facilities for the comfort of the public.

The arrangements contemplated for handling baggage are exceptionally complete, and will care for the heaviest movement without delay or congestion. The express and postoffice buildings will be equipped with every modern device for expediting the enormous amounts of such traffic daily handled at this terminal.

MOTIVE POWER AND ROLLING STOCK.

Corresponding to the two classes of service, two radically distinct forms of motive power are needed for operation. For hauling fast and heavy through trains electric locomotives of great weight and high speed are required; for suburban service the rolling stock need not be essentially different from that developed on multiple-unit urban rapid transit railways. The motor cars which have been designed for the latter service show, in fact, close similarity to the type of equipment used in the New York Subway and (more recently) on the newly-equipped electric lines of the Long Island R. R. The locomotives, on the other hand, represent a wholly new design, the product of thorough study by the American Locomotive Co. and the General Electric Co., both of Schenectady. They are of unprecedented power, have shown satisfactory performance on running test, and promise satisfaction as regards maintenance and durability.

Descriptions of these locomotives in some detail have been given in these columns within the past eighteen months,* from which the following summary is compiled.

The locomotive is of 2-8-2 type and weighs 95 tons in working order. It carries four motors of novel construction, one on each driving axle, giving a total rated power of 2,200 HP., or about 3,000 HP. maximum. The armatures are mounted directly on the axles, and the field magnets are integral with the locomotive-frame. Each motor has two field poles, in the horizontal plane; the pole faces are vertical planes, instead of being concave, as usually. This permits considerable vertical play of the magnets with respect to the armature, which fact is taken advantage of, to decrease the weight carried directly on the axle (without springs), by mounting the magnet frame on springs. The motors have ordinary series winding, and are arranged to be connected either all four in series, or two in parallel and the two sets in series, or all four motors in parallel. The motor circuits are handled by an individual switch system, with master controller, the regular Sprague-General Electric multiple-unit system. The switches or contactors are arranged along the central corridor of the cab. This system permits two locomotives to double-head, and puts both under full control from one cab.

Current is collected by four third-rail shoes on either side, or by two overhead contacts fitted on a linked diamond frame for raising and lowering; both third-rail shoes and overhead contacts are actuated by air. Automatic airbrakes, pneumatic sander, whistle and bell-ringer are fitted. Air is furnished by a twin compressor driven by two motors, the capacity being 75 cu. ft. free air per min., at a reservoir pressure of 130 lbs. per sq. in.

The two-wheel truck at either end is connected to the main frame by a radius arm, and, as the driving wheel base is only 13 ft., the locomotive is very flexible laterally.

The principal dimensions and statistics of this design of locomotive are given in following table:

DIMENSIONS OF NEW YORK CENTRAL ELECTRIC LOCOMOTIVE.

GENERAL.	
Class of traffic	Fast passenger
Gage, standard	4 ft. 8½ ins.
Total length over buffer platforms	37 ft.
Extreme width	10 ft.
Height of top of cab	14 ft. 4 ins.
RUNNING GEAR.	
Driving wheels, 8, diameter	44 ins.
Truck wheels, 2 front, 2 rear, diam.	36 ins.
Trucks	Swing center
Diameter of driving axles	8½ ins.

*Eng. News, 1904, I, 522, and 1904, II, 450. The latter article is much the more complete, giving full descriptive data, and is accompanied by a section of the locomotive, many detail views, and performance curve sheets. The conductor rail and collecter shoe shown in that article are, however, of the ordinary top-contact form.

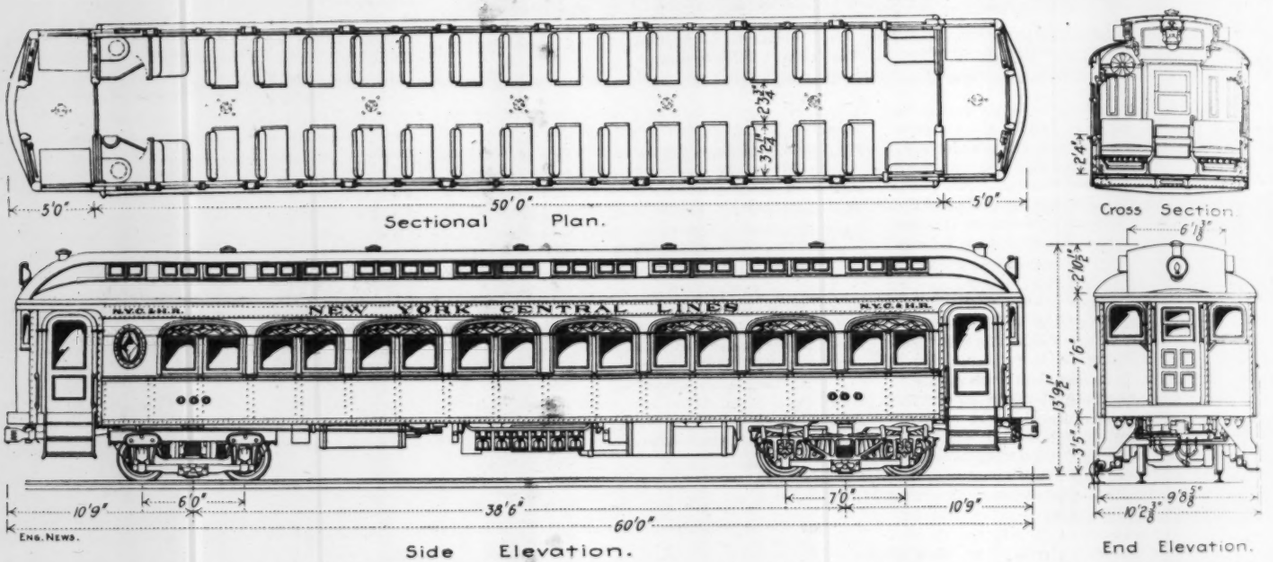


FIG. 7. GENERAL PLANS OF NEW STEEL CAR FOR MULTIPLE-UNIT ELECTRIC TRAINS, SUBURBAN TRAFFIC IN ELECTRIC ZONE, N. Y. C. & H. R. R. R.

WHEEL BASE.	
Driving	13 ft.
Total	27 ft.
WEIGHT.	
On driving wheels	138,000 lbs.
On truck wheels	52,000 lbs.
Total, in working order	190,000 lbs.
POWER.	
Supply, direct current	600 volts.
Conductors	Overhead and third-rail
Motors, four G E—84—A, each 550 HP. rated	2,200 HP.
Maximum power of locomotive	3,000 HP.
Normal full-load current	3,050 amp.
Maximum current	4,300 amp.
Normal drawbar pull	20,400 lbs.
Maximum starting drawbar pull	32,000 lbs.
Speed with 500-ton train, on level	60 mi. per hr.
Control: Sprague General Electric multiple unit, with automatic current-limiting lock in the master controller. Series-parallel, from four motors in series to four in parallel.	

The locomotive was designed to enable an acceleration of 0.5 to 1.0 mi. per hr. per sec.

Wheel base of motor trucks	7 ft.
Wheel base of trailer trucks	6 ft.
Diameter of motor truck wheels	36 ins.
Diameter of trailer truck wheels	33 ins.
Seating capacity	64 passengers.

The weight of car body, in both motor cars and trailers, is 53,000 lbs., without electrical equipment. The light weight of the motor car is 102,600 lbs., and of the trailers, 78,600; the weight per passenger being 1,603 lbs. and 1,228 lbs., respectively. The weight of the usual sixty foot wooden coaches used in steam service is about 61,800 lbs., or 965 lbs. per passenger.

On account of eliminating the weight of the steam locomotive, however, the total weight of train for a given number of passengers is less for the electric train than for the steam train; the comparison for a six car train shows a total weight of 310.6 tons (electric) against 350 tons (steam), or, respectively, 1,618 lbs. and 1,823 lbs. per seated passenger.

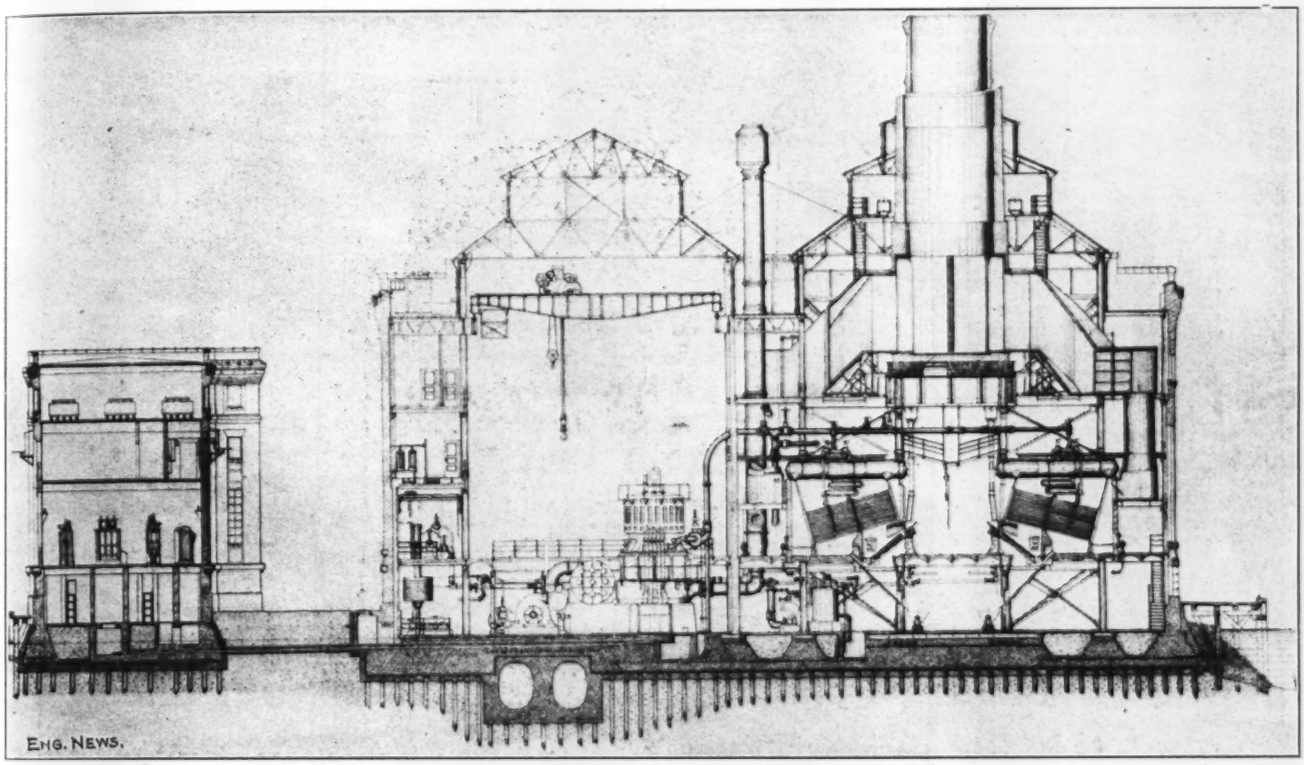


FIG. 8. CROSS-SECTION OF ELECTRIC GENERATING STATION AT YONKERS, N. Y., FOR POWER SUPPLY TO ELECTRIC ZONE, N. Y. C. & H. R. R. R.

to be obtained with trains up to 800 tons, and to give a maximum speed of 60 mi. per hr. with a 500-ton train. In actual test on a 4-mile track near Schenectady the results in both speed and acceleration were, it is reported, wholly satisfactory.

The type of car developed for the suburban service is exhibited in general form by the drawing, Fig. 7. The car is of all-steel construction, and will seat 64 persons. It is equipped with two motors, is lighted and heated electrically, and in summer is ventilated and cooled by electric fans. These cars are now being built by the American Car & Foundry Co., at Berwick, Pa. They will be operated in trains made up of motor and trailer cars, equipped throughout with Sprague General Electric Multiple-unit control. The motor cars and trailers are alike except for the motors, motor trucks, control apparatus and air compressors.

The frames and bodies of these cars are made of structural steel and pressed steel shapes, the window and door casings and frames and the mouldings are of pressed steel, and the fittings of metal or fireproof material.

The principal dimensions are as follows:

Length over all	60 ft.
Length of car body between vestibules	50 ft.
Width over all	10 ft. 2⅝ ins.
Width over sheathing and platform floor.	9 ft. 8⅞ ins.
Height from top of rail to top of roof	13 ft. 9½ ins.
Total wheel base	45 ft.

Each motor car has one truck equipped with motors, and one idle truck. The weight per axle, loaded, on the motor truck is 32,390 lbs.; on the trailer truck of motor cars 23,300 lbs.; on the trailer cars the weight per axle, loaded, is 21,890 lbs. There are two 200-HP. General Electric No. 69-c motors on the motor truck of each car. They will give an acceleration of 1¼ mi. per hr. per sec., and a speed of 52 mi. per hr.

The general interior arrangement is similar to that of 60-ft. coaches used in steam service. The seats are set transversely and there are no side doors in the body of the car. Both men's and women's toilet rooms are in one end, while at the opposite end are two seats set longitudinally, one in each corner. The vestibule platforms are 5 ft. long and the full width of the car body. They are fitted with steps for use with low station platforms, but the steps are covered with automatic lifting trap doors for use with the high station platforms in the Electric Zone. The trap doors are so arranged that they can be operated by a trainman standing on the platforms. The steps are of metal protected with metallic safety treads.

The vestibuled side doors slide into pockets in the side of the car. The vestibule end doors leading from car to car, when open, swing into such a position as to enclose the motorman's air brake valve and the control apparatus. The vestibule at the head end of the leading car forms the motorman's compartment.

The center sills of the car flooring consist of two 8-in. I-beams, each continuous between platform and sills. The side sills are formed by the sides of the car, which are built up as plate girders with the steel sheathing plates forming the web, a continuous 6x6x½-in. angle the bottom flange and a continuous special bulb section at the belt rail the top flange. The side posts extend in one piece from sill to plate. Three special cross bearers, extending from side to side of car under the sills and spaced between the body bolsters, act as floor supports and transfer load to the sides of the car, thus avoiding deflection of the centre sills. By this arrangement the centre sills are kept in alinement and retain their full value as compression members under buffing stresses. The end sills consist of steel channels. The ends of the car body and the vestibule are built up of rolled and pressed steel shapes and steel plates, the bulkhead being designed so as to form a pocket for the sliding doors at the ends of the car. An anti-telescoping steel plate is secured under the center sills and platform end sills. The buffer beam is made up of white oak faced with steel plate.

Floor supports consist of steel angles set longitudinally, supported by the cross bearers. The flooring is made up of galvanized Keystone section sheet steel laid transversely and covered with cement flooring. This is protected with maple floor strips.

The carlines consist of steel angles in one continuous length from side plate to side plate, forming the contour of the lower and upper decks. The ventilator frames are of pressed steel, forming a water-tight housing for the upper deck sash. The lower deck eaves molding is a metal shape designed so as to form a drip. The upper deck eaves molding is a steel angle with wood moulding attached to take the canvas roofing. The roof is formed of fireproof composite board, secured to furring strips fastened to carlines and

purlins, the composite board being covered with heavy cotton duck. The furring is all fireproofed ash.

The interior finish consists of composite board and plate steel relieved at joints and connections by rolled steel moldings. Seats are of the "Walkover" type, upholstered in fireproof rattan.

The cars are fitted with both Pintsch gas and electric light, the former being necessary on account of the cars being used in combined steam and electric service before the completion of the entire electric work. There are five Pintsch gas lamps with four jets each, and 42 16-c. p. electric lamps, of which 30 are hung as pendants from the clear-story sills, and 12 are hung in pairs over the aisle. Each vestibule has a Pintsch deck light and two electric lights. Each end of the motor cars is equipped with an incandescent headlight placed on the roof of the vestibule.

Systems for heating by either steam heat or electricity are also provided, the "Gold" system of steam heat being used. The electric heaters are located under and attached to the seats. An electric fan is located at each end of the car for cooling and ventilating.

The cars are equipped with high speed automatic air-brakes, each motor car being a unit in itself and having its own compressor and motorman's brake valve. The apparatus is so arranged that locomotives when coupled to trains can operate the system in the usual manner. A Lindstrom hand brake is installed on each platform.

Each car is equipped with a complete air signal apparatus, with air whistles in motorman's compartments which can be cut out when locomotive is attached.

The switch panel chamber is located at the trailer end of the car on the same side as the control apparatus. The rear of the panel is accessible from the men's toilet room. This panel contains all the switches for the control of the car and for the air compressor and lighting, heating and ventilating apparatus.

In addition to the ordinary brakes, whistle and steam hose couplings there are two bus line and two control train line coupler sockets on each end of the car. All the cables under the car are carried through loricated conduits. The motor leads from motors to car body are covered with spiral brass armor.

The trucks are of four-wheel, swing bolster type, built by the American Locomotive Company. The journals on motor trucks are 5½x10 ins., and on trailer trucks 5x9 ins. The motor truck wheels have cast steel spoke centers. An extended hub takes the gear, which is shrunk on the hub. The wheels are keyed to the axles. The side frames of motor trucks are of cast steel and the end frames of steel angles. Side bearings are "Norwood" style F, ball bearings. Bolsters are of cast steel with centre plates cast in the same piece.

The brake beams are inside hung; the brake heads are of M. C. B. type of malleable iron, and the brake shoes are of the stripped back type. Bolster springs are two double elliptics of 9⅜x5 in. plates. The journal boxes on motor trucks are Symington, and on trailer trucks, McCord M. C. B. pedestal type. The third rail shoe beam is attached to the journal boxes.

The motors have nose suspension and each motor is provided with safety lugs cast on the shell, one on each side of the motor nose.

The arrangement of the windows in pairs, with an elliptic arch over each pair, resembles the designs used in Pullman cars or in heavy coaches of recent design for through service, and the general appearance of the cars is very attractive.

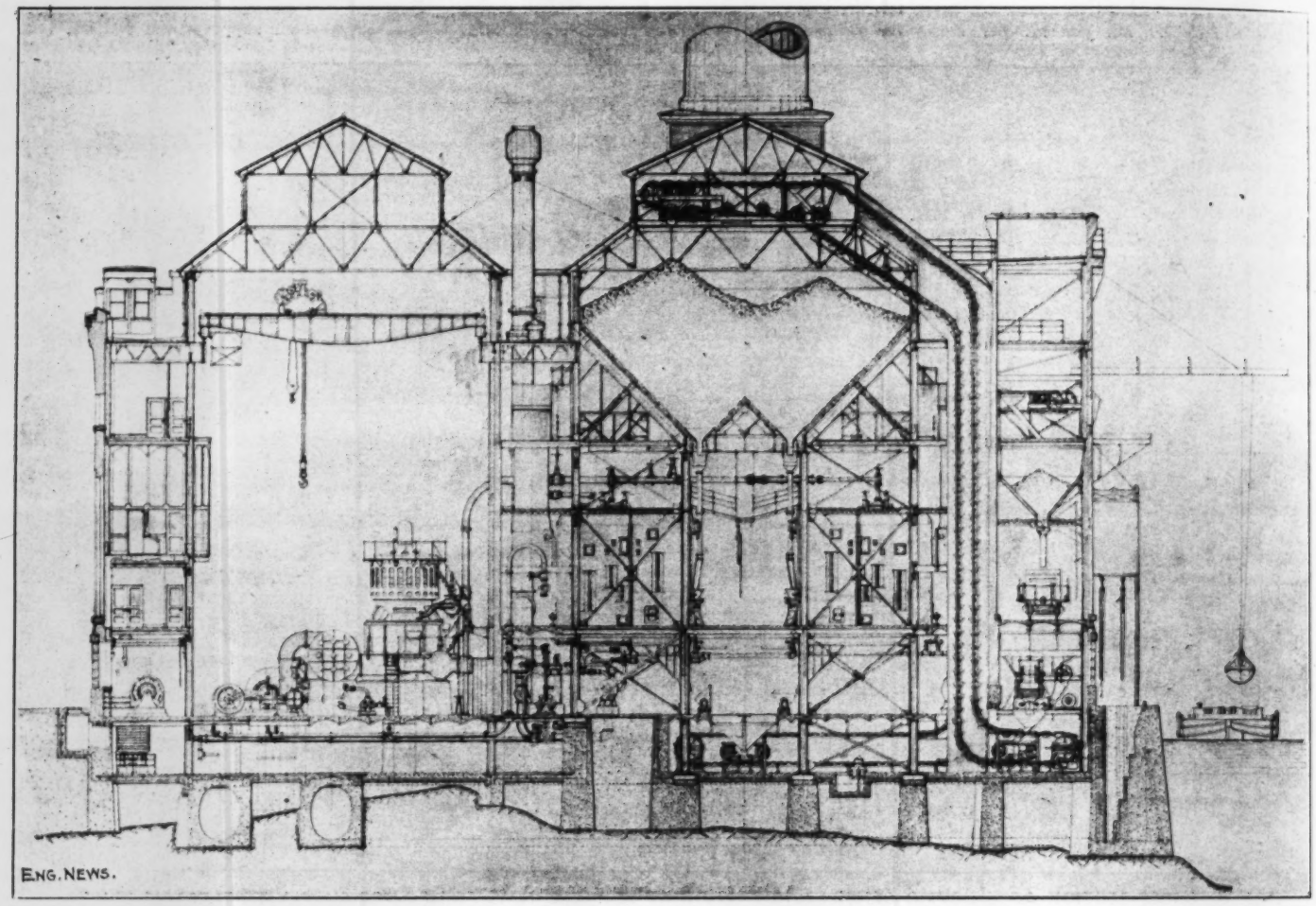


FIG. 9. CROSS-SECTION OF ELECTRIC GENERATING STATION AT PORT MORRIS, NEW YORK CITY, FOR POWER SUPPLY TO ELECTRIC ZONE, N. Y. C. & H. R. R. R.

CURRENT SUPPLY; GENERATING STATIONS AND SUBSTATIONS.

In the study made in 1901 by Mr. B. J. Arnold of train operation over the division between Grand Central station and Mott Haven, it was concluded that a daily average input of 1,800 KW. at the contact shoes of the locomotives would be required, or a maximum momentary input of 3,000 KW. at the contact shoes. On this basis a 5,000 KW. station, or say three generating units of 2,000 KW. each, would have sufficed. [illegible] the plans of the company have developed [illegible] then is best typified by the fact that the ge[illegible]ting capacity now being provided is 60,000 [illegible] in two power stations of 30,000 KW. ultim[illegible]ca-pacity each.

It may also be noted that Mr. Arnold c[illegible]ded that, for the Mott Haven service alone, a [illegible]ect-current generating station for direct dist[illegible]on of 600-volt current, would be cheapes[illegible]ow that electric working for 35 miles instead [illegible]ve miles is to be supplied, this conclusion [illegible]ally does not hold. The familiar system of hi[illegible]ol-tage generation of polyphase alternating [illegible]ent, transmission to step-down and rotary co[illegible]er substations, and direct-current supply from these to the track conductors, is employed.

The generating stations are located: One at Yonkers, on the Hudson Division; the other at Port Morris, on the Harlem Division. They are cross-connected, and with their total of 60,000 KW. capacity can carry a train service much greater than that now operated by steam. Each station has a main building 167 ft. × 237 ft., 105 ft. high, enclosing the generating rooms, boiler rooms and coal bunkers; and a separate switch house located about 40 ft. away. The station design gives a volume of station of 102 cu. ft. per KW. capacity, and a ground area of building of 1.32 sq. ft. per KW.

Cross sections of the two stations are shown in drawings herewith, Fig. 8 representing the Yonkers powerhouse, and Fig. 9 the Port Morris powerhouse. The two stations are similar in general design, but the foundations, due to local conditions, differ materially.

At Port Morris the concrete foundation piers were carried down to solid rock, which was sufficiently near the surface. The site was enclosed by cofferdam, utilizing a concrete river bulkhead as part of the wall, and was laid dry. Irregularities in the rock surface, and disintegrated portions, made the maximum height of pier 34 ft. Intake and discharge tunnels for the circulating

system of the condensers were excavated in the rock. Concrete tunnels for steam and other piping to the turbine room were built under the floors, and the whole area was filled with sand around the piers for columns and boiler and generator foundations, to the level of the floor. The pipe tunnels, where below water line, are waterproofed with coal-tar pitch and felt.

The Yonkers powerhouse is built wholly on land under water, on the river side of the railway

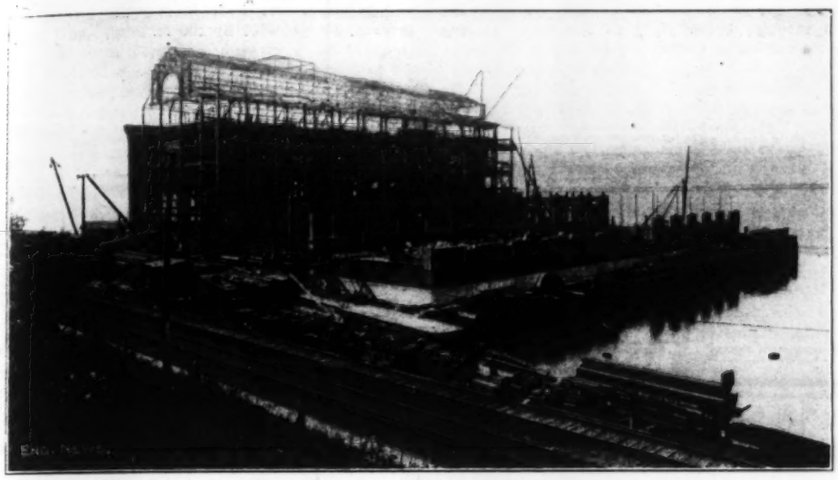


FIG. 10. PHOTOGRAPH OF YONKERS GENERATING STATION IN COURSE OF CONSTRUCTION. (Sept. 29, 1905.)

tracks; the ground on the land side rises abruptly and is valuable for residential purposes. The water over the site had a depth of 8 to 16 ft., on a bottom of sand and gravel well suited for a pile-and-concrete foundation. (At all other possible sites near the load center of the division, great depth of soft bottom was found, or other unfavorable conditions.) Piles were driven to refusal, the area was then enclosed with a cofferdam of 12x12 timbers, fitted with tongue-and-groove joints of 3 × 4-in. strips spiked on. The ground, when laid dry, was excavated, the piles were cut off in general at about 8 ft. below M. H. W., and the bottom of the concrete was laid 1 ft. below the pile heads. Under the intake and discharge tunnels for the condensers the concrete reached a depth of 16 ft., and under the coal and ash hoist tunnel a depth of 13 ft. below M. H. W. In this powerhouse the steam and other piping is carried under transverse galleries in the turbine room, instead of under the floor.

The main part of the concrete foundation is 4 ft. thick, bringing its top to El.—5; six inches above the pile heads a waterproofing of felt and coal-tar pitch is laid, which is carried up the side walls to above water level. Six-ply waterproofing is used in all horizontal planes, five-ply in vertical planes, and four-ply around ducts exposed to surface or tide water. Above the horizontal course of waterproofing there is a reinforcing course of steel rods, 1-in. round rods being laid in two directions at right angles. The foundation includes 5,540 piles, 16,500 cu. yds. concrete, 27 tons reinforcing rods, and 9,000 sq. yds. waterproofing.

Above the foundations, the powerhouses have a steel framework (designed to give no inaccessible surfaces), walls of brick and tile, floors of concrete and roofs of concrete slabs covered with copper. Architecturally the effort was made to secure a striking and attractive exterior, especially at night, and a well-lighted interior. The main windows are in a row of 11 arched openings on each side, of 10-ft. span, and above each arch are three small windows lighting the upper gallery. The window frames are built-up steel, the mullions of glass and steel. In the gable ends the lines of the end roof truss are left exposed, and the spaces between the members are filled with concrete slabs.

Each powerhouse has two Custodis radial-brick stacks, 15 ft. 6 ins. inside and 250 ft. high above grates. They are supported on steel columns and a concrete and steel staging 40 ft. above the boiler room floor, the main boiler room alley passing underneath.

In interior arrangement the power stations are divided by a brick wall into the turbine room, 69 ft. × 231 ft. 8 ins., which is of clear height to the roof, and a boiler room 88 ft. × 231 ft. 8 ins., over which the coal bunkers, of 3,500 tons capacity, are placed. At Port Morris there are three galleries on one side of the turbine room, the first gallery being used as a shop, the second as an operating gallery and the third for offices. At Yonkers the level of the first gallery is carried across the room as the operating floor with walkways between the generators. The exciters are placed under the galleries on the level of the operating floor, the operating gallery being immediately above them and the top gallery being used for offices and shops.

Coal delivered at the power stations on cars is dumped from the cars into pockets, from which it is taken by suspended-flight scraper conveyors to crushers, where it is reduced to the proper size for handling with the mechanical stokers; thence it passes into a pocket conveyor, which lifts it to the top of the building and delivers it to longitudinal conveyors of the scraper type, which dump it into the coal bunkers over the boiler room. From the bunkers it is delivered through vertical down-spouts to Roney mechanical stokers, operated by steam.

The ashes drop from the grates into hoppers, from which they are collected in push cars of one ton capacity, running in an ash tunnel in the boiler room basement. These cars dump into a hopper, from which the ashes are lifted by means of a bucket conveyor into an ash storage bin directly over the coal trestle, from which they can be dropped through a spout in the bottom of the hopper into a car. Cars on the trestle are spotted by means of an electric winch.

Coal delivered by boat is hoisted in a clam-shell bucket of one ton capacity, operated by a steam hoist.

The coal handling capacity is 80 tons per hour and the ash handling capacity is 25 tons per hour. The maximum coal consumption at the power stations will be about 220 tons per day.

Aside from the hoist for unloading coal from boats, which is operated by steam, the coal handling apparatus is all driven by electric motors. The conveyors are driven by 220 volt three phase induction motors, varying in capacity from 7½ HP. for the ash conveyor, to 40 HP. for the coal crusher and conveyors.

Each power station is arranged for a battery of 24 Babcock & Wilcox water-tube boilers, rated at 625 HP. each, all located on one floor and arranged 12 on each side of a central alley. Sixteen boilers will be installed in each power station for initial operation. The total heating surface of each boiler is 6,250 sq. ft. and the grate surface is 112 sq. ft., giving a ratio of 55.8. The boilers are designed for a normal working pressure of 185 lbs. and the steam will be superheated to 200° F. above the temperature due to steam pressure. Each section of the power station containing four boilers is equipped with one Epping-Carpenter boiler-feed pump of the duplex outside-packed piston type. The pumps are designed for hot water and each pump has a capacity to supply 8 boilers under full load conditions. The feed water heaters, made by the Taunton Locomotive Mfg. Co., are of the closed type corrugated tube Wainwright counter-current design.

The piping is all mild steel, with flange joints of a modified Van Stone pattern. It will be supplied and installed by M. W. Kellogg & Co. Four boilers are piped direct to one turbo-generator and by means of cross connections adjacent boilers can be arranged to supply turbo-generators of the next group. The sectional system of piping has been followed throughout for the auxiliary machinery.

The turbine room of each power station will

FIG. 11. CABLE TOWER NEAR HIGHBRIDGE, NEW YORK CITY, SHOWING CHANGE FROM CABLE TO AERIAL TRANSMISSION LINE ON CROSS-CONNECTING CIRCUIT BETWEEN THE PORT MORRIS AND YONKERS GENERATING STATIONS.

be equipped with a 50-ton Alfred Box Co. traveling crane, having an auxiliary 10-ton hoist.

Each power station is designed to accommodate six 5,000-KW. turbo-generator units, four of which are being installed for initial operation. The turbines are of the Curtis five-stage vertical type, and are about 15 ft. in diameter at the base and 35 ft. high from the floor to the top of the generator. The turbine structure is mounted upon a cast iron base, forming an exhaust chamber, in which is provided the opening to the condenser and to free atmospheric exhaust. The shaft of the turbine is separated from that of the generator above, connection between the two being made by a coupling so that the machine can be readily taken apart. The shaft is borne by a step-bearing consisting of two cast-iron blocks, between which water is used for lubrication under a pressure of 800 lbs. per sq. in., exerting a sufficient force to slightly raise the moving structure.

One individual pump is provided for each turbine for the lubricating system, and in addition to this, two larger pumps, in connection with two accumulators, insure uninterrupted pressure at the step-bearings.

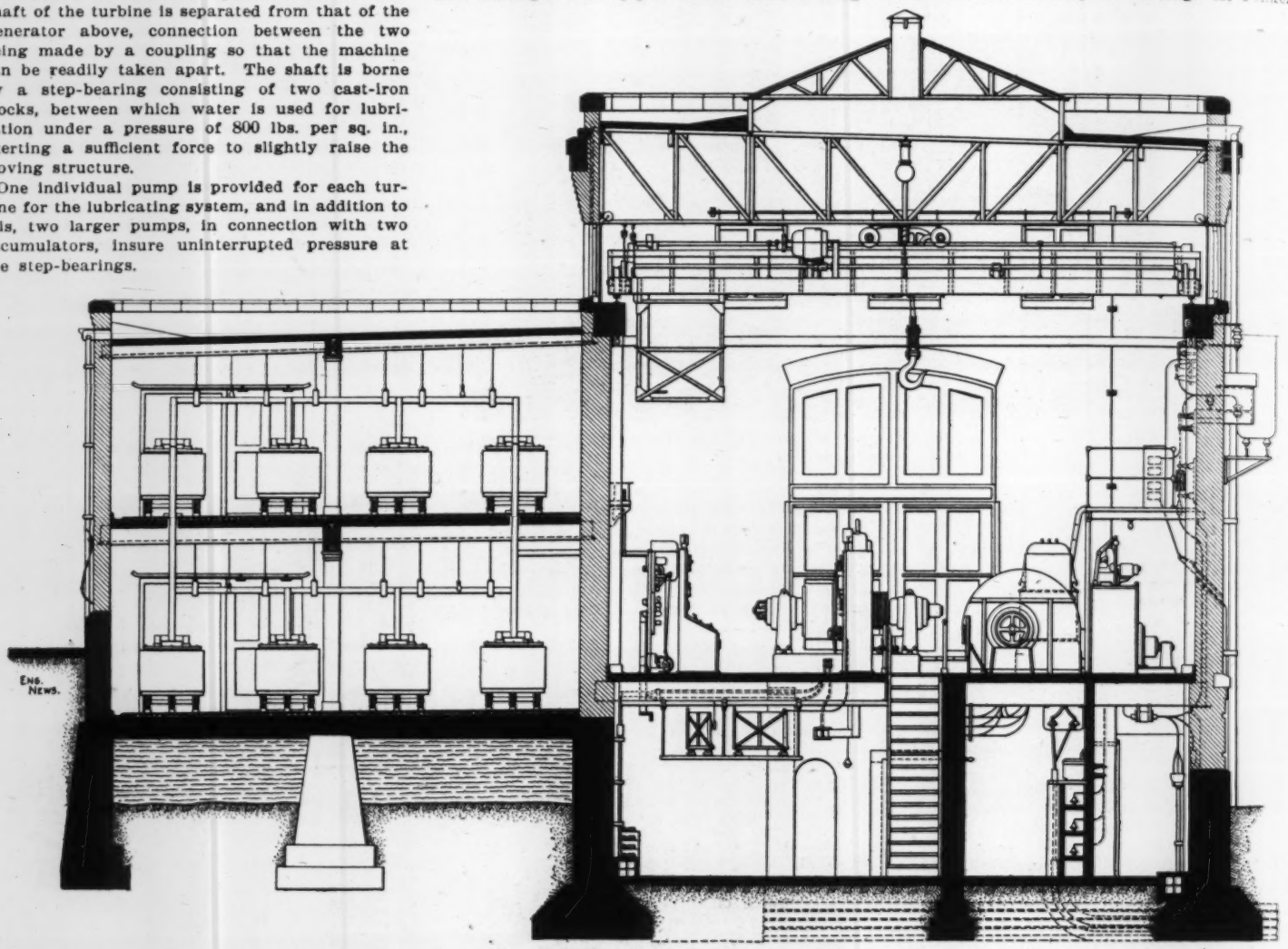


FIG. 12. CROSS-SECTION OF TYPICAL SUBSTATION, ELECTRIC ZONE, N. Y. C. & H. R. R. R.
Approximate Scale: 1 in. = 9 ft.

The governing will be effected by successive opening and closing of automatic hydraulically operated valves which deliver steam to the different sections of two sets of nozzles.

The turbines will be fitted with two centrifugal devices to check any excess of speed. After either one of these devices operates, the next revolution of the machine will bring it into engagement with a lever which will trip the main steam valve.

The condensing apparatus is external to the turbines. The main condensers, by H. R. Worthington, are of the counter-current surface type; each is directly connected to its turbine base and contains about 17,000 sq. ft. of cooling surface. They are guaranteed under full load to maintain a vacuum of 28 ins. at 30. ins. barometer, with cooling water at a temperature of 70° F. The apparatus auxiliary to the condensers is composed of independent units. Circulating water pumps are of the centrifugal type directly driven by horizontal reciprocating engines. The dry vacuum pumps are of the rotative flywheel type, with air and steam cylinders in tandem, erected on a common base. The hot well pumps are of the two-stage turbine type and are driven by direct connected electric motors.

The intake and discharge circulating tunnels for the condensing system are elliptic in shape, 7 ft. 3⅞ ins. by 9 ft. 11 ins.

The generators each have a capacity of 5,000 KW. and are wound for three-phase current of 25 cycles and 11,000 volts pressure. The armatures are star-connected and the neutrals are grounded through individual cast iron grid resistances, connected to a common ground bus, limiting the ground current to an amount sufficient to operate the line overload relays. The leads of the generators are brought down to the floor through brass pipes to the ducts leading to the high tension switches, the arrangement being such that no high-tension conductors are exposed in the turbine room.

The exciter system at each power station will consist of two 150-KW. turbo-generators and one 150-KW. induction motor generator furnishing current at 125 volts pressure; also one Electric Storage Battery Co.'s exciter storage battery of 74 cells, having a capacity of 1,200 amp. for one hour, with spare space in the tanks for increasing the capacity to 1,800 amp. for one hour. Exciter generators and battery are connected to two independent positive busses and one common negative bus.

The stations will be operated from the operating gallery on one side of the turbine room. The arrangement of the switchboards in this gallery is symmetrical and all cables and copper connections running to the switchboards are carried in concrete trenches under the floor. The main operating switchboard containing all control switches and instruments necessary for the operation of the station is located in the centre of the operating gallery; a set of two exciter switchboards is located on each side. The main operating switchboard as well as the exciter switchboards are enclosed in an operating booth constructed of steel and wire glass. Three field switchboard panels are located outside on each side of the operating booth. A a. c. and a d. c. light and power switchboard on either end of the operating gallery complete the switchboard installation in the turbine room.

At both power stations switchhouses have been provided separate from the main building with the idea of obtaining the best conditions for the installation of high-tension switching apparatus, and at the same time increasing the safety of operation. At Port Morris the switchhouse is 50 ft. 10 ins. wide by 100 ft. long. At Yonkers the switchhouse and the sub-station for that district are combined in one building 37 ft. 4 ins. wide by 255 ft. 4 ins. long, the switchhouse occupying 147 ft. 8 ins. of this length. In the switchhouses are installed the high-tension switching equipment, consisting of bus-bars, oil switches, instrument transformers, etc.; also such instruments as are required for the complete equipment of generating stations, but which are not essential for the operator. The switchhouse contains further, auxiliary boards which allow the main operating switchboard in the turbine room to be put out of service for cleaning and repairs. These boards will also permit the operation of the station should, by an accident, the main operating board become disabled.

The high tension busses are installed in the basement of the switchhouses; the generators are connected to them by means of a main switch and two selector switches. The feeders are equipped with selector switches only. Overload relays are installed in the generator and feeder circuits, but the generator relays will operate only under very extreme conditions. In the generator circuits, in addition to overload relays, reverse current relays will be installed; these, however, are connected to indicating lamps only, not tripping the oil switches. All re-

lays are of the inverse-time-limit, bellows type. All high tension connections and apparatus are located in the basement of the switchhouse and no such apparatus is located on the first floor, except the oil switches to which connections are made from the basement through the floor. On the second floor are located the load dispatcher's office, the exciter battery with booster and switchboard, laboratory, storeroom, toilet rooms and the apparatus for the hot air heating and ventilating systems.

The arrangement of oil switches and connections is such that the apparatus belonging to one generator and three feeders forms a unit which is entirely separated from the others by fireproof walls in the basement. All connections between oil switches and bus bars are made with bare copper tubing 1¼ ins., outside diameter, the construction being such that practically no insulators will be required. All cables coming through the duct system from the powerhouse enter manholes in the basement of the switchhouse, the arrangement being such that high tension cables enter the high tension compartments entirely separated. Low tension cables enter through manholes in a passage separated from the high tension compartments by a fireproof wall and are brought up in enclosed chases in the wall, so that they are positively insured against any accidental connection with high tension conductors.

The oil switches have a rated capacity of 500 amp., except the bus tie switches, which have a rating of 1,200 amp. The switches are of the motor-operated type.

All high-tension cables and the majority of the single conductor low tension cables, within the powerhouses, are cambric insulated and lead covered, the insulation being 10-32 in. for high tension cables and 4.32 in. for low tension cables, with a lead cover 3.32 in. Single conductor cables will be used for connecting the generators with the oil switches. Multiple-conductor cables for instrument and control wiring have a combined cambric and rubber insulation.

In each power station a Load Dispatcher's Office has been arranged for the proper distribution of power over the system, and in order to give quick relief in case of accident or trouble. Only one of these will be in service at a time. Each Load Dispatcher's Office will be equipped with a record board indicating, by means of lights and plugs, which generators, lines, rotaries, etc, are in or out of service and which switches are open or closed. An independent telephone system exclusively for the use of the load dispatcher, interconnecting both power stations, all sub-stations, and the train dispatchers in the Electric Zone, will be installed.

The contractors for the foundation work were: At Yonkers, Walter Butler; at Port Morris, D. C. Weeks & Son. The steel work, 2,800 tons in each powerhouse, was furnished by the American Bridge Co. The Thompson-Starrett Co. erected the Port Morris superstructure and Butler Bros. Construction Co. the Yonkers superstructure. The steam turbines and generators, and the entire switching equipment, were built and will be installed by the General Electric Co.

The high-tension transmission system connecting generating stations and substations consists mainly of overhead lines supported on steel towers. Within the closely settled parts of New York City, however, underground transmission is used. The changes from underground to overhead occur generally at substations; in other cases special buildings, cable towers, are used. Fig. 11 shows one of these towers.

The high-tension transmission system is quite complex. In general, each substation has at least one independent three-phase line from a power station, and in addition has lines connecting it with adjacent substations. The two power stations are connected by a separate three-phase line. All lines consist of three 4/0 stranded copper conductors. In the underground lines each circuit is contained in a three-conductor cable, sheathed with lead; in the overhead lines the conductors are bare, and occupy the points of an equilateral triangle 36 ins. on a side. The overhead lines are carried on structural steel poles, spaced 150 ft. on tangents and closer on curves, with Yellow Pine cross arms. The underground lines are laid in vitrified duct, waterproofed and surrounded with concrete. The manholes in the cable ducts have removable shelves, of slate or soapstone, resting on iron pins, on which shelves the cables are carried across the manhole space.

Substations for the conversion of high-tension alternating current into low-tension direct current are located along the railway divisions served, at points marked in the map Fig. 1. There are eight of these substations, one of which is located at Grand Central Station, and one at the Yonkers powerhouse. They are quite similar in size, covering a ground area of 3,600 to 3,800 sq. ft., except the Grand Central substation whose ground area is 4,800 sq. ft. The general arrangement may be gathered from the drawing Fig. 12, representing a transverse section through a substation. The station comprises a transformer and converter room, and a two-floor battery room separated from the former by a fire-wall. The installation of batteries is a characteristic feature of the New York Central's distribution system. It was adopted in part as a means of smoothing out momentary excessively heavy drafts of current, and in part as an insurance against interruptions of traffic which may result from accidental shut-down of one or both generating stations, short-circuits of cables, etc.; a contingency which, however remote under proper operation, must be faced as a possibility.

The converters are arranged along the middle of the main room of the substation. Along the wall adjoining the battery room is the low-tension switchboard, while along the opposite or outside wall are the high-tension switches. The transformers on the main floor are connected to the high-tension switches on the one side and the converters on the other by cables under the floor. Thus the circuits within the substation run across the machine room, from the side where the high-tension lines enter to the side where 660-volt direct-current track feeders leave. All apparatus is located on the main floor, except the lightning arresters, which are on a gallery on the high-tension side. The switchboard, which controls both high and low tension, stands on the low-tension side. Each unit of machinery, consisting of one converter and its transformers, etc., is arranged in the manner described. Longitudinally each station has three such units, of capacity each 1,000 KW. or 1,500 KW.; the larger size of unit is used in the Grand Central and Mott Haven substations.

The rotary converters are of three-phase type, with sextuple connection, which gives them the advantages of three-phase and six-phase construction. The high-tension wiring within the substation, where bare, is of copper tubing giving excellent and simple mechanical construction.

At each substation the third-rail is separated, and an insulated section of about one train length is intercalated, in order to prevent a train bridging across from one main section to the following. From the substation there are led eight track feeders, one to each of the four third-rails of the two adjacent main sections; an additional feeder supplies by four branches the third-rails of the intercalated section. Running continuously along the right-of-way, entering and leaving each substation through circuit-breakers leading to the low-tension busses, is an auxiliary feeder, consisting of one or more copper cables either overhead or underground. This auxiliary feeder, of conductivity equal to the 70-lb. third-rail, has taps leading to the four third-rails every 3,000 feet. Each group of four taps, and each tap of the four, contains a circuit-breaker which can be tripped electrically from the nearest substation. The taps and circuit-breakers are contained in a small section-house. No return copper is provided.

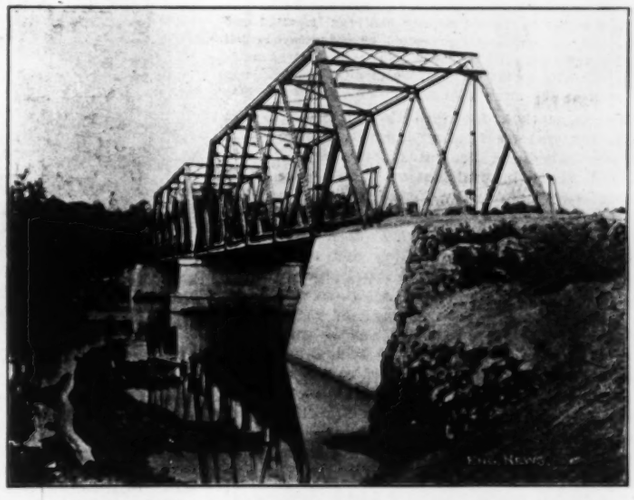
The work which is briefly summarized in the foregoing article has been in continuous execution for the past two years. It will not be finally completed, it is thought, before five years from now; its total cost will be in the neighborhood of $60,000,000. The first electric trains, however, will be put into service probably before the close of another year from the present.

AMERICAN STEEL HIGHWAY BRIDGES IN THE PHILIPPINE ISLANDS.

By H. L. Stevens.*

During the year 1905 there have been purchased for erection in the Province of Sorsogon nine steel highway bridges. These bridges were the first steel highway bridges to be erected in the provinces since the American occupation and were therefor in some measure an experiment. The Philippines have so many small rivers to bridge that there is sure to be a great many steel bridges erected in the next few years and an account of the methods used together with suggestions for the better detailing and handling of future shipments may be of interest to American engineers.

On arrival in Manila the bridges must be transhipped to one of the smaller inter-island boats. At the port of destination the steel must be unloaded on native cascos, conveyed to the shore and thence hauled to the bridge site by carabao or ox carts. An erection gang consists of an American foreman and ten or twelve natives, and their equipment is a hand forge, a home-made "dolly" and a couple of hammers. This force will drive from 50 to 200 field rivets per day depending upon the openness of the work.



A STEEL HIGHWAY BRIDGE OF AMERICAN MANUFACTURE AT BARCELONA, P. I.

On account of the long sea voyage, frequent handling and exposure to the tropical climate the paint used in painting the steel in the shop scaled off and some pieces corroded badly. Several of the members were also badly bent. Many of the smaller details that might have been shop-riveted to the larger members, were shipped loose and were lost. Some of these were afterwards recovered, others had to be cut to order in Manila. Approximately 25% of the field rivets could have been shop-driven.

The people of the Islands are very critical of American goods and those articles sold here, especially those purchased by the American officials on behalf of the Philippine Government, should be the best that can be furnished.

American steel bridges for this country should

*Late Provincial Supervisor, Province of Sorsogon, P. I. Present address, Tomah, Wis.

be shop-painted with the best paint, they should be carefully detailed and loose pieces and field riveting should be reduced to a minimum. The templet work should be so good that the unskilled native laborer will have no trouble bolting up the members ready for riveting. The people in the province take great pride in the steel bridges erected the past year and others will be purchased in the near future.

SOFTENING WATER FOR LOCOMOTIVE BOILERS.*

By T. W. Snow.†

Until within the past five years the water service of railways has been considered a matter of quantity rather than quality, and the majority of railways in the United States are still using the old improvident methods of furnishing water for the locomotives. One of the large railways entering Chicago uses annually about 9,300,000,000 gallons of raw water at an average cost of 3 cts. per 1,000 gallons, while on another road the cost is 23 cts. per 1,000 gallons. The latter has now put the matter in the hands of a water expert, and he is rapidly rebuilding and reorganizing the water stations, so that in another year this road will be able to make as good a showing as the first one.

Of the many foreign substances contained in water, there are but four that give us much of any trouble in forming scale; these four, however, make up 98% of the scale adhering to the interior of the boiler, and may be designated as the carbonates and sulphates of lime and magnesia. These are commonly present in our western waters and sometimes to an alarming degree. It has only been within the past few years that American manufacturers and railway companies have given any serious consideration to the subject of water purification. While the technical world has known for 50 years or more of the Porter-Clark process of removing scale-forming matter from water, we are practically only just waking up to the situation in this country. The Porter-Clark process is extremely simple, and consists of adding ordinary lime and soda ash in proper proportions to the raw water. The mechanical methods of doing this are many and varied. The chemical method remains the same in this and all countries. All important mechanical devices in use in the old country had been imported into this, and are variously represented by concerns engaged in the water softening business. Since there is no practical difference in the chemical treatment it only remains to consider the mechanical application.

Mr. Snow then described the operation of the Davidson water-softening apparatus, which was fully described and illustrated in our issue of April 2, 1903. Both intermittent and continuous types of water-softening plants were referred to. One of the latter, now being built at the shops of the Chicago & Eastern Illinois Ry., at Danville, Ill., will have the chemical feeding and mixing apparatus located on top of a stand-pipe adjacent to the elevated water tank. All chemicals, however, are prepared on the ground floor and pumped to the chemical feed tank on top, requiring but a few minutes each day of the attendant's time. The automatic chemical feeding and mixing device consists of a tilting hopper with two compartments which are filled and emptied alternately, the only power required to operate it being the weight of the water from the main water supply. All water must pass through the oscillating vessel, which is thus a motor and also a meter. The power derived from the moving tilter is sufficient to operate the chemical pumps and to work the stirring arms within the chemical tank.

An installation was put in this year on the Missouri Pacific Ry. The division from St. Louis to Hoxie has some very bad waters, and it was decided to put in three of these water purifying plants to see what the effect would be on the locomotives. The reported number of engine failures on that division in February was 21 daily. In going over the division before the work was finished I noticed an auxiliary engine at nearly every station, for fear of a failure. After six months of use at this place, and taking the average month with the same months of last year and for a period of six years, the Master Mechanic said the direct saving was about $2,000 per month. That is for boiler makers and boiler tubes, and does not take into account the indirect savings, which are probably much larger. Not only did they have these 20 or more auxiliary engines doing other useful work, but the improved regularity in the moving of trains proved a very large item.

One railway running from Chicago to the Missouri River has about 20 of these stations. The cost of chemicals for treating each 1,000 gallons varies from 0.6 cts. to 2½ or 3 cts., according to the hardness of the water. In none of these instances have we added any additional labor to the water station on account of putting in this chemical apparatus. The machine is very simple; it picks up its own chemicals and weighs them out, and it does this automatically without any labor or attention. The operator needs only to mix his chemicals on the ground floor, which is done quickly, and then pump them up into the chemical tank above. Of course, the work must be done accurately. The operator weighs out his chemicals according to the formula he receives. The chemist of the road instructs him exactly what to do, and it is his business to see that his chemicals remain the same.

DISCUSSION.

MR. G. M. DAVIDSON.*—It may be asked what does the railway company get for the expenditure it makes in putting up these plants? It has been my privilege for the last three years to have had charge of about 25 plants, and we have kept very accurate account of the cost of operating them, and tried to get some figures showing the value that the railway company received. One of the big items of saving is the decrease in the cost of repairing boilers. We have 17 plants on one division (250 miles), supplying an average of 160 locomotives, all large, and the service is pretty hard. There were two repair stations and two boiler shops. The year before we started these plants we employed 36 boiler makers and 42 helpers. The year after we started the plants we had 23 boiler makers and 35 helpers, decreasing the cost of labor of maintaining the boilers about 35%.

Another item of interest to the operating officers is the question of leaky flues. Anybody who has ever had anything to do with getting trains over a railway in winter time knows how troublesome leaky flues are. The year before these plants were in use we had 544 cases of engine failures due to leaky flues; the year after only 99. We had 33 fire box failures the year before, and 20 the year after; 6 arch-tube failures the year before, 1 the year after; making a total of 583 engine failures before the plants were put in, and 120 after. Our mechanical department is frank enough to give the water softening plants credit for the decrease in failures of about 79%.

Another interesting item in this connection is one that specially appeals to the manager, and is the increased tonnage rating of the engines. If we can put three or four more cars on to an engine than we did formerly, that is the thing to do, and that is what the managers want. Our statistics show that on this division the year before the water softening plants were in use we had 2,934,130,000 ton-miles, and the year after 3,154,000,000. In other words, we increased the ton mileage 7½%, and at the same time bought less coal. The year before we used 28.7 lbs. of coal per 100 ton-miles, and the year after 27½ lbs. We increased the ton mileage 7½% and decreased the cost of coal per 100 ton-miles about 4.2%. We find we are able to do the same business with a smaller number of locomotives than we were before we went into the water softening business. There are a good many reasons for this; one is that the trains are not delayed so much on the road, so there is not so much delay in getting to the terminals.

Another point is, we have been able to increase the mileage of engines between the times of being sent to the shops. Formerly a locomotive would go to the shop because the boiler needed repairing long before the machinery was worn out. Since putting in the water softening plants it is the machinery that generally needs repairing first.

*Abstract of a paper read at the meeting of the Western Society of Engineers, Chicago, Nov. 1.
†Manager, Otto Gas Engine Works, Chicago.

*Chemist and Engineer of Tests, Chicago & Northwestern Ry., Chicago.

PARABOLIC CONCRETE ARCH BRIDGE OVER PINEY CREEK AT 16TH ST., WASHINGTON, D. C.

A concrete arch bridge of unusual type has recently been put under construction at Washington, D. C. The arch ring has the curve of a parabola and a clear span of 125 ft., and the spandrels are hollow, a framework of reinforced concrete between curtain walls carries the floor slab. The spandrels and the floor slab are of reinforced concrete, but the arch ring is not reinforced except for a net of face bars to resist surface cracks. As will appear the unusual feature is the form of the arch ring; parabolic masonry arches are rare, and it is claimed, and we suspect rightly, by the engineers that this is the first parabolic concrete arch in America.

The general appearance of the bridge is indicated by the drawing reproduced in Fig. 1. The length of the bridge is 272 ft. over all, the span of the arch is 125 ft., and its rise is 39 ft. Examination of the drawing shows two parallel arches side by side. The reason of this is explained as follows: The sum appropriated by Congress for the construction of the bridge was $[illegible]000. This permitted the construction of a bridge only 25 ft. wide, not nearly the width of the street of which it was to form a part. It was decided, therefore, to design the bridge in such a way that the crossing could be widened in the future, yet have the present structure complete in itself. A

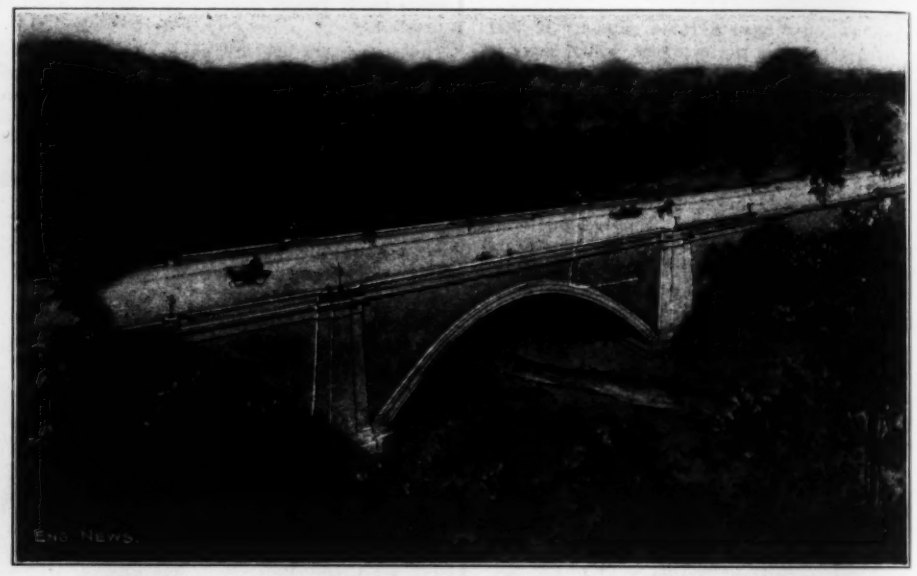
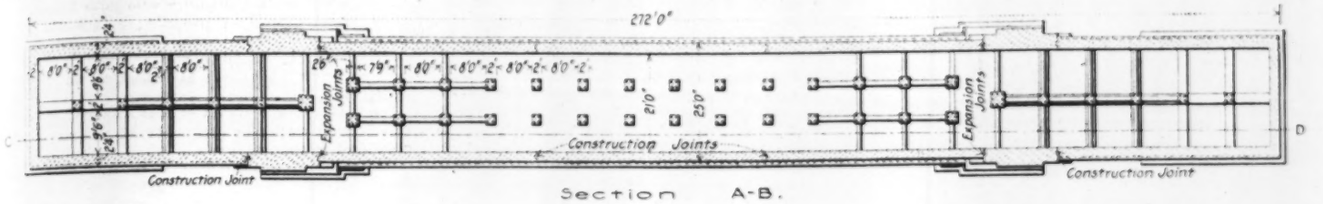


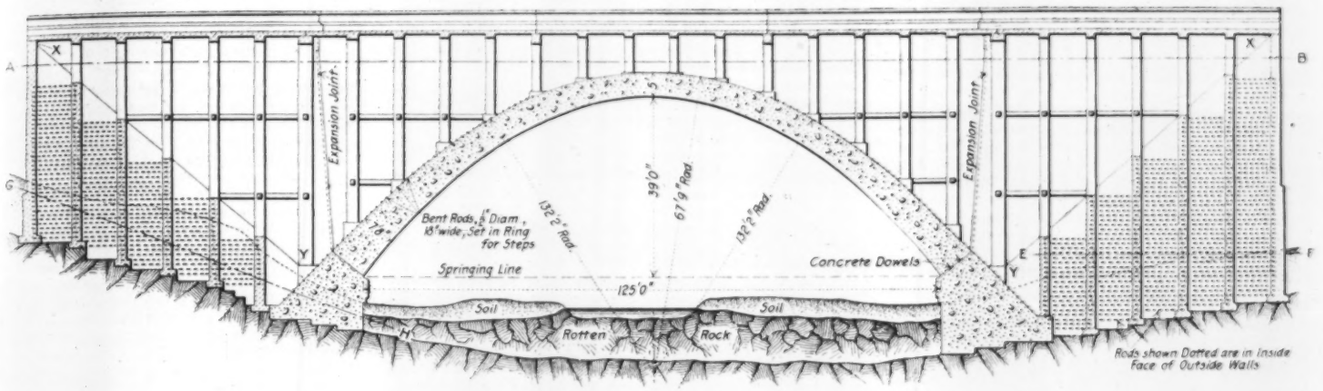
FIG. 1. VIEW OF CONCRETE ARCH BRIDGE ACROSS PINEY BRANCH AT SIXTEENTH ST., WASHINGTON, D. C.

leaf was taken from European practice; following the example set by the engineers of the Luxemburg Bridge (Eng. News, Feb. 27, 1902), it was planned to build two arches 25 ft. wide parallel to each other with a space between them, but to construct only one of these structures at first. The present bridge is, therefore, eccentric with the axis of the street; in fact, the center line of the street falls wholly outside the bridge. When in the ripeness of time the money is available for completing the work, the twin structure will be built on the opposite side of the street, and the space between the old and the new arches will be bridged by a slab of reinforced concrete.

The structural character of the bridge is shown in general detail by Fig 2. In these drawings the arch ring is the first feature to call for attention. For this the parabolic form was adopted because the neutral axis and the line of pressure for uniform load practically coincide, while for eccentric load their deviation is very small. For dead load the total concrete structure figured at 150 lbs. per cu. ft., was assumed; for live load a weight of 40 tons on axles 20 ft. apart was assumed. The total dead load as figured is 200 lbs. per sq. ft. over the full arch ring. The thickness of the ring was proportioned for these loads so as to keep the maximum compression stress on the concrete at 300 lbs. maximum.

The spandrel construction consists of two solid spandrel walls, and between them two rows of columns, all supporting a ribbed floor slab. The longer spandrel columns are stiffened laterally by





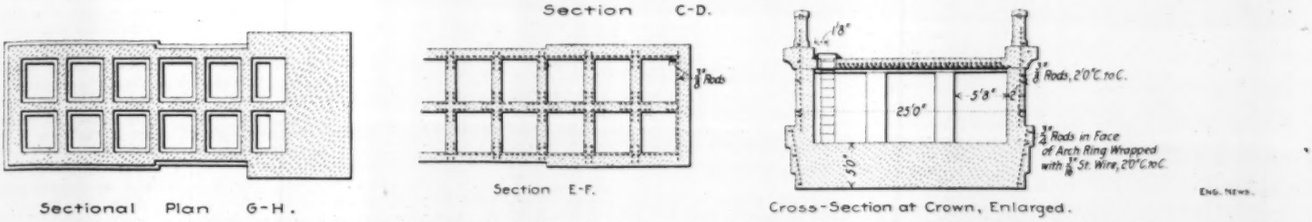


FIG. 2. GENERAL STRUCTURAL DETAILS OF PINEY BRANCH CONCRETE ARCH BRIDGE.

horizontal braces between columns in both directions, the transverse braces running into the spandrel walls. Columns, walls and bracing are all reinforced.

The arch spandrel construction is continued over the abutments with certain modifications. First, only one row of spandrel columns is used instead of two ,and the lower portions of these columns are connected by walls to form closed cells, which are filled with earth. The lines XY define the tops of the diaphragm walls. These interior walls are not reinforced, but the spandrel walls below lines XY have an inside reinforcement in addition to the regular outside reinforcement. This inside reinforcement in shown by Fig. 2, and also by the half cross-section, Fig. 3, of the abutment on the vertical plane DD. Above the walls the abutment columns are connected by horizontal braces, as are the columns over the arch ring.

Details of the column and brace reinforcement and of the reinforcement of the spandrel walls are shown by Fig. 4. Regarding the wall reinforcement, it may be noted that the rods are spaced 2 ft. apart both horizontally and vertically. They are lapped 18 ins. at joints, and the consecutive joints are staggered 4 ft. The bonding of the brace reinforcement into the columns and spandrel walls and of the column reinforcement into the footings is to be noted.

To provide for expansion and contraction, the arch span is separated from the abutments by expansion joints cutting the spandrel walls and the floor slabs. The locations of these joints are shown clearly by the drawings of Fig. 2, and Fig. 5 shows their construction in detail. It is to be noted further that the spandrel walls are subdivided by construction joints shaped like the expansion joints, but being simply planes of weakness formed by constructing fresh concrete against concrete already set instead of true joints separated by a compressible filling. It will be noted that interior columns over which comes the expansion joint in the slab is made much stronger than the other columns to resist the bending stress due to the operation of the joint.

The reinforcement of the floor slab is indicated by Fig. 4. The slab is stiffened by transverse ribs over the columns. These ribs or girders are reinforced as follows:

Girder, Size. ins.	No. Rods.	Size Rods. in.	Spacing c. to c. ins.
24 × 16	6	1¼	4
24 × 24	6	1¼	4
30 × 16	7	1¼	4
36 × 18	9	1¼	4

It will be noted from the drawing, Fig. 5, that alternate rods are bent up at the ends of span and carried over the columns. The slab reinforcement proper consists of transverse ⅝-in. rods spaced 6 ins. c to c, and longitudinal ⅞-in. rods spaced 12 ins. c to c.

The bridge as described was planned in the office of Mr. W. J. Douglass, Engineer of Bridges, District of Columbia, under the direction of Col. John Biddle, Engineer Commissioner, and Capt. Jay J. Morrow, Assistant to the Engineer Com-

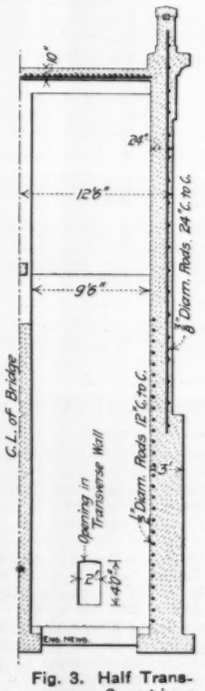


Fig. 3. Half Transverse Section Through Abutment on Line DD, Fig. 2.

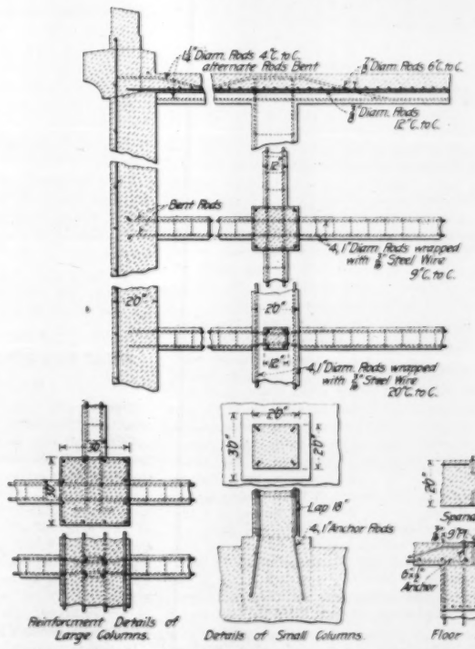


Fig. 4. Details of Floor and Spandrel Columns and Bracing.

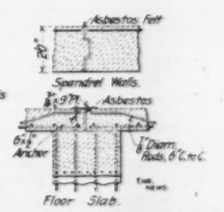


Fig. 5. Details of Expansion Joints in Spandrel Walls and Floor Slab.

missioner. The official specifications contain several features of interest. It is provided that stone dust must be used in the exterior work instead of sand, and the contractor is privileged to use stone dust throughout if he wishes. If sand is used where permitted, it is specified that it may contain as much as 10% silt; tests made by Mr. Douglass have indicated that this silt contains a large percentage of silicious matter, and is not detrimental to the mortar. The following sections of the specifications are quoted nearly in full:

FORMS.—All forms for all classes of concrete shall be closely laid and strongly braced. All lagging shall be tongued and grooved and the studding for all the work shall be dressed or sawed to an even thickness. All forms except by consent of the engineer shall be held in place by means of bolts, so made that the outer 3 ins. of the bolts can be removed after the forms are taken down, and the remaining holes shall be filled with mortar. If ⅞-in. lagging is used the studs shall not exceed 18 ins. on centers, and if 2 × 8-in. studs are used the wales shall not be less than 8 × 8 ins. These wales on the basis of 2 × 8-in. studs shall not be further apart than 8 ft., nor shall the bolts which hold them and which have diameters of ¾-in. be further apart than 8 ft.

DETAILS OF CONSTRUCTION.—(a) The concrete for the arch shall be placed in layers which shall be perpendicular to the lagging of the center or parallel thereto in so far as may be directed by the engineer. These blocks shall have the full depth of the arch and extend the entire width of the center. The blocks will be formed by placing forms upon the center parallel to the axis of the arch and perpendicular to the lagging. The back block shall be built up as continuous work. The back of each arch shall be kept true to the curve by strongly braced tongue and groove lagging up to a point about 45° from the springing line, or if the contractor prefers he may build the back of this arch to straight lines which shall be tangent to the extradorsal curve of the arch shown on the drawings. After this point is reached the tack shall be carried truly to the curve by grading the concrete to templets cut to fit the curve. The exposed backs of the main arches shall be given a mortar coating, either built up with the concrete in the usual manner, or applied as a plaster at least one ½ in. thick, before the concrete has set, and this coating shall be troweled to a reasonably smooth surface. (b) The concrete of all showing walls shall be carried up so as to bring the work at the close of each day to a horizontal joint so that the new work which will join on to it will show a horizontal regular joint if any. It is the intention not to show any joint in the face work as nearly as this can be effected. A day's concrete work shall not exceed 7 ft. in depth on the basis of the forms hereinbefore described. All edges of all finished concrete work shall be cast as full as practicable. Where satisfactory edges are not attained, the contractor shall file them so as to remove the ragged edges.

REINFORCEMENT.—The contractor shall furnish and emplace all the steel reinforcement shown on the drawings. It shall be of medium steel according to the manufacturer's standard for highway bridges, or if the contractor so desires, he may substitute for the reinforcement here shown a standard patented steel reinforcement, which, however, must be approved by the engineer. If he substitutes bars having a mechanical bond with the concrete he will be permitted to use a minimum cross section 75% of that shown on the drawings for the several classes of reinforcement there shown. If he use any patented bar, the cost bid shall cover the cost of all royalties and engineering advice. In such cases he must submit with his bid drawings clearly showing in detail the size of the several bars proposed to be used by him for reinforcement, the amount, position, lap and all other data which will be necessary to make his intentions clear. All steel shall be clean, free of oil or paint and reasonably free from rust.

GENERAL DESCRIPTION OF CENTERS.—The centers shall be built for the full width of the bridge (25 ft. between faces of arch rings). The contractor will not be allowed to use centers having trussed spaces greater than 20 ft., but must carry posts down from the bow to similar foundations. Bows in no case shall exceed 6 ft. 6 ins. on centers. They shall be stiffly sway-braced, both transversely and longitudinally. The foundations for the centers shall be of concrete of the same kind and according to the specifications hereinbefore specified for the permanent work. They shall be of such size as shall not permit of a settlement greater than ¼ in. under the maximum loads they are designed to carry. The tendency of the centers to rise at the crown as they are loaded at the haunches must be provided for in the design, or, if not, the centers must be temporarily loaded at the crown and the load so regulated as to prevent distortion of the arch as the work progresses.

MATERIALS.—Merchantable long leaf pine timber shall be used throughout excepting that sills, corbels, wedges, and all other lumber subjected to side pressure shall be of white oak of the following specifications: White oak must be free from decay, splits, shakes, sawed true and out of wind and square edged, full-sized, free from large or loose knots or any other defects which would seriously impair its strength or durability. The wedges shall be of straight-grain oak only. All material shall be subject to the approval of the engineer. Stresses in all material for the centers will be computed on the basis of ⅓ of the breaking strain on the material used, in accordance with the tables of Kidwell and Moore, for wooden beams and columns, 1899. In design of the center care shall be taken so that the center shall be stiff. The joists, caps and bows shall not have a deflection exceeding ¼-in. under the full load of the arch, or the partial load of the arch, the concrete being figured as a liquid having a weight of 150 lbs. per cu. ft.

JOINTS.—No dependence will be placed in nails, except for fastening the lagging, for securing the wedges and for minor details, and then only upon the approval of the engineer. All joints shall be made with bolts and with straps or gussets of steel or iron, if in the judgment of the engineer they are necessary in the design submitted.

LAGGING.—The lagging must be made in two thicknesses if the contractor so desires. The top layer to be tongued and grooved lumber not less than ⅞ in. thick and the lower layer dressed to a matched top surface when in place. Lagging shall not have a deflection under the full load of the arch, or under the partial load, exceeding ⅛ in. The concrete being figured for partial load as a liquid having a weight of 150 lbs. per cu. ft. The lagging shall be kept wet for three weeks after the keying of the arches.

STRIKING CENTERS.—The crowns of the centers shall be raised above the intended height of the finished arches to allow for settling when the centers are being loaded and when struck. The centers shall be struck when directed by the engineer, which direction will not be given until the masonry above them has been completed up to the level of the bottom of the coping. Wedges shall have a batter of 1 in 10 ins. and the pressure on the same shall not exceed 300 lbs. per sq. in. The grain of the same shall run with the batter and their contact faces shall be planed true and smooth for their entire width and length, and, if so ordered by the engineer, they shall be lubricated to facilitate the striking of the centers without unnecessary jar. If the contractor wishes to use sand boxes to lower the centers he shall submit the details of the same for approval to the engineer. The sand boxes shall be waterproof, and the sand used in the same shall be thoroughly washed to remove all silt and thoroughly dried before using. The centering shall not be paid for directly, but the payment of the same shall be included in the price for the arch concrete.

In planning the exterior finish of the bridge, it was considered wise to make no attempt to hide the material of which it is constructed. There will be no simulation of cut stone work, but in order to prevent the monotony of the single color, the arch ring, the spring blocks, the pilasters, the belt course under the coping, the coping itself and the parapet will have a mortar facing which will have the yellow tone given to it by the river sand. The balance of the exterior face of the bridge will show a bluish concrete. The mortar will be picked over with stone picks to bring out the blue color, and for the same reason gneiss stone dust is used in its composition in lieu of sand.

The contractors for the bridge are the Penn. Bridge Co., of Beaver Falls, Pa., the contract price being $42,731. Congress has appropriated $50,000 for the work, and $20,000 of this are immediately available. We are indebted to Mr. W. J. Douglass, Engineer of Bridges, Washington, D. C., for the information from which this account of the work has been prepared.

WHAT HAS BEEN ACCOMPLISHED AT PANAMA.*

By Theodore P. Shonts.†

I propose to talk as a practical man to practical men who are themselves engaged in large commercial enterprises, and who know from experience the difficulties to be met and the enormous amount of thought and labor involved in the inauguration of great undertakings in the United States. You will be able to appreciate, therefore, how every difficulty was aggravated in an enterprise of the magnitude of the Isthmian Canal, in which the preparatory work had to be carried on two thousand miles from the base of supplies. But this is not all: The work had to be done in a hostile climate and under health conditions which, through centuries of neglect of all sanitary principles, had become a menace to the lives of all persons save natives of the tropics.

In order, therefore, to make the Isthmus a place fit to live in and to work in, there were three fundamental tasks which had to be performed in advance of all others.

First. Thorough sanitation of the Isthmus.

Second. Providing suitable habitations for all classes of employees.

Third. Providing a system of food supply which would afford to all employees opportunity of obtaining wholesome food at reasonable cost.

1st. In regard to sanitation: When the United States began this work there were no systems of water-works, of sewerage, or of drainage on the Isthmus. The people depended largely on unprotected cisterns for their water supply, filled during the rainy season, and on barrels filled from neighboring streams, all breeding places for mosquitoes. The filth of ages had accumulated around the dwellings and in the streets, undisturbed except when washed away by torrential rains. Pools of stagnant water had existed for years in proximity to dwellings and insect-breeding swamps lay undrained adjacent to the cities and many of the towns. Seventy per cent of Panama is now supplied with pure mountain water, fed from a storage large enough to furnish sixty gallons per day to each inhabitant after its present population shall have increased one-half. Fifty per cent. of a complete modern sewerage system has been installed, and work on the remainder is being carried rapidly forward. The first million of brick for paving its streets are on the ground. The city has been fumigated time and again, first house by house, to stop the spread of disease, and again as a unit, that is, the entire city at one time. A large force is just finishing a thorough cleaning of the city—the first scrubbing it has had during its centuries of existence; and Governor Magoon, under whose jurisdiction all this work has been accomplished, is arranging to raze many of the worst shacks and replace them with modern sanitary buildings. Within a year, it may confidently be predicted, Panama will be a city well watered, well sewered, well paved and clean and healthy.

What has been done for Panama is being done for Colon and every important labor camp across the Isthmus. Work on Colon's water reservoir is well under way, and temporary measures are being employed to safeguard the city's health pending the report of a Board appointed to recommend plans for permanent improvements. An abundant supply of pure water from mountain springs has been provided at Culebra and at other important labor centers along the line of the canal, and adequate drainage is being installed in them also.

In these sanitary undertakings 4,100 men are now employed. So effective has been the work that yellow fever has been virtually extirpated from the Isthmus. In June last there were 62 cases of yellow fever there; in July, 42; in August, 27; in September, 6, and in October, the worst month of the year for yellow fever, 3—no one of the latter among the employees, and all originating many miles from the line of the canal. In regard to general health conditions, I was told, when on the Isthmus in October, that there were over a hundred less patients in Ancon Hospital than there had been for many months, although we had brought in 4,000 additional laborers during the previous two months, and it was from the new arrivals that the hospitals were usually recruited.

To fully understand what has been accomplished by our sanitary work it is only necessary to compare the present rate of sickness with that which prevailed on the Isthmus when the French were in possession. In August, 1882, the second year of the French occupancy, with a force of 1,900 men, the death rate was 112 per 1,000. In August, 1905, with a force of 12,000 men, there were only 8 deaths, or two-thirds of a man per 1,000.

We have established a hospital system which includes a large hospital at Colon and another at Ancon, and a number of smaller hospitals at convenient points along the line. The one at Colon is built on piers over the Atlantic Ocean, and patients there have at all times the benefit of cool and invigorating sea air. That at Ancon is one of the largest and best equipped in the world, situated on the hill above Panama and commanding a superb view of mountain and sea.

The management and service of the hospitals are on a par with the natural advantages and beauty of location. Colonel Gorgas, who is in direct charge of hospitals, has organized a staff of doctors and nurses for which it would be difficult to find a superior anywhere. Mr. Isham Randolph, one of the members of the Consulting Board of Engineers who recently visited the Isthmus, said, in a letter published on his return: "The hospitals are a source of just pride to our people. If sickness could ever be regarded as a boon, it may be so thought of in Ancon and Colon."

2d. In regard to providing quarters for the employees. The commission inherited from the French Company more than 2,100 buildings, all in bad condition. During the past year, 649 of them have been repaired, 58 new buildings have been erected, and 67 more are in course of construction; two new hotels, three stories high and containing from 55 to 60 rooms each, have been completed, and authority has been granted for eight others, a portion of which are under construction at the present time. Work is in progress also on cottages for married

*Extracts from an address before the American Hardware Manufacturers' Association, at Washington, Nov. 9.
†Chairman, Isthmian Canal Commission.

employees and on bachelor quarters. In this work of construction 2,400 men are employed, and additional carpenters are being sent out with every steamer. This work is being pressed forward with the utmost vigor.

2d. In regard to food supplies. This was the most serious problem that confronted us. If we couldn't feed the men, we couldn't build the canal. Owing to the fact that the natives never look beyond their present necessities, no surplus food supply ever accumulates. This normal condition of no surplus was greatly intensified by the almost total failure of the crops for the two preceding years, by the abandonment by agricultural laborers of their farms back in the hills for work on the canal, where they received higher pay for shorter hours, and by quarantine against the port of Panama on account of bubonic plague, which prevented the arrival of food stuff from neighboring provinces.

We were thus brought face to face with the problem of feeding 12,000 men, with base of supplies 2,000 miles away.

We immediately arranged to open local commissary stores at every important labor camp, to provide mess houses, and to furnish food, both cooked and uncooked, to all employees at cost. We cabled orders to have our steamers equipped with refrigerating plants; we arranged for the erection of a temporary cold storage plant at Colon; and we purchased refrigerator cars for immediate shipment to the Isthmus, thus establishing a line of refrigeration from the markets of the United States to the commissary stations of the Isthmus. We also purchased from individual lessees the equipment in existing hotels and assumed their management ourselves. The net result of these efforts is that to-day we are affording to all employees opportunity to obtain an abundant supply of wholesome food, cooked and uncooked, at reasonable prices. The silver men—by which I mean the common laborers—are being fed for 30 cts. per day, and the gold employees—by which I mean those of the higher class—at 90 cts. per day, and it is good food in place of bad.

The only really valuable instrument essential to canal building acquired by our government in its purchase from the French was the Panama Railroad. But this instrument, like all the others whose wrecks cover the Isthmus, had been neglected and its equipment allowed to become obsolete. If the docks, wharves, warehouses, terminal yards, locomotives and cars of the Panama Railroad had been in good repair, which they were not, they still would have been entirely inadequate to properly care for and handle the small commercial business the road was transacting. The existing facilities, poor as they were, were rendered less efficient by the entire absence of any mechanical appliances on the docks to assist in receiving or discharging the steamers' cargoes. The negro laborer was the only power employed; he was at once the only hoisting machine and the only traveling crane in use. Imagine, then, the congestion which necessarily ensued when the accumulated orders in the States began to arrive in large quantities on both sides of the Isthmus. To aggravate the situation, while the deluge of arriving material was at its height, the commercial business of the road increased nearly 50% over the year before; and at the moment when we thought affairs could get no worse, two cases of bubonic plague at La Boca resulted in two consecutive quarantines at that place, completely tying up that outlet for 60 days. Furthermore, the personnel of the Panama Railroad as acquired had not been educated on modern lines, and therefore was completely paralyzed when confronted with the onerous conditions caused by this congestion. It was necessary, consequently, to begin at once the construction of new wharves equipped with modern mechanical appliances, and of large terminal yards at both ends of the road; of extensive warehouses; of suitable machine shops, and of a modern coal hoisting plant, which will reduce the cost of handling coal from ship to engines from $1.30 to about 12 cts. per ton.

We have also purchased new and more powerful locomotives, larger cars for both passenger and freight services, and heavy steel rails for relaying the road, and have strengthened the bridges to enable them to carry the heavier equipment. We have reorganized the personnel of the road, putting into the higher positions experienced, aggressive, up-to-date men, with the result that with the old equipment and facilities they have cleared up during the last thirty days an accumulation of over 12,000 tons of commercial freight. With the advent of our increased dock facilities, terminal yards now nearly complete, and new power and equipment now arriving, the road will be in a position to handle efficiently and economically a vastly larger volume of business than heretofore.

While all this necessary work was in progress, the task of purchasing, forwarding and distributing the enormous quantity of materials and supplies of all kinds was receiving our constant and most careful attention. The purchases included not only the items entering into the permanent plant, but also those required for the preliminary work. The approximate total cost of our purchases was about $9,000,000.

It should be borne in mind that at the time when orders for most of these items were placed, the industries of the United States were crowded with domestic business, and were unable, consequently, to make prompt deliveries. It should be borne in mind, also, that after machinery had been manufactured here and set up, it had to be taken apart, shipped 2,000 miles over steamship lines already taxed to their full capacity, and on arrival on the Isthmus had to be again set up before ready for use. Then, too, on account of many reports as to the prevalence of yellow fever on the Isthmus, it was very difficult at a critical time for concerns furnishing material to get steamers to take it there, because of fear that their crews might become infected and their vessels might be quarantined when they wished to return to the United States. Finally, the steamers of the United Fruit Line from New Orleans, which had been carrying a considerable amount of the freight going to the Isthmus, were put out of service on account of yellow fever in that city.

To the various causes of delay mentioned is to be added the requirements of law that all bids for materials used in government work shall be advertised for. This compels a delay in all cases of from ten to thirty days.

Furthermore, in addition to the purchases for the canal, the following have been ordered for the Panama Railroad: 500 40-ton box cars, 12 caboose cars, 10 refrigerator cars, 6 passenger coaches, 24 locomotives, 2 wrecking cranes, 1 locomotive crane, 1 pile driver, 3 100-ton track scales, 1 modern coal hoisting plant, 1 cantilever crane coal hoisting plant.

In regard to all equipment purchases, both for the canal and the railroad, it should be stated that the gage of the Panama Railroad being wider than the standard gage in the United States made it impossible to use second-hand rolling stock of any kind; all locomotives and cars had, therefore, to be built to order. The elimination of yellow fever and the establishment of better systems of housing and feeding the employees have enabled us to recruit our working forces till those assigned to the material and supply division now number over 2,100 men.

I have so far endeavored to give you an idea of the difficulties which we have had to encounter and overcome in order to make the Isthmus a place fit to work in, and to collect the tools with which to work. So far as actual excavation and dredging are concerned, we have not endeavored to accomplish much. As a general principle, in which I think you will all concur, it is inadvisable to attempt to run a railroad before the tracks are laid. We are now working, however, six steam shovels in Culebra cut, which is the largest single factor in the construction of the canal, and have removed approximately one million cubic yards of material By this work we are accomplishing two things: First, we are putting the levels of the cut in proper condition for the installation of the largest number of machines which can be effectively operated; and, second, we are gathering data which will be useful in future estimates of the cost of canal construction. In the Culebra work 2,600 men are now employed. We are also building railway tracks and yards, and are dredging at both ends of the canal, so far as advisable until the question of type of canal is decided. It should be understood that all the work we have done is applicable to any type of canal.

The question of labor is a grave and perplexing one. We have advanced far enough to know that we can secure a sufficient supply of labor from the tropics, so far as numbers are concerned. The question of quality is a very different matter. Unless a much greater efficiency can be developed than is secured at present, we shall have to look elsewhere.

To these tropical laborers we are paying from 80 to 90 cts. per day in gold, and it is estimated that we do not get more than 25% of the efficiency of labor in the United States. This is the kind of labor to which we are compelled to apply the eight-hour law—that is, to aliens who know nothing of the law's existence until they arrive on the Isthmus. Such application will increase the labor cost of canal construction at least 25%, and will add many unnecessary millions to the total expenditure.

In my opinion it is a mistake to handicap the construction of the Panama Canal by any laws save those of police and sanitation. I want to go on record here that the application of the eight-hour law, of the contract labor law, of the Chinese exclusion act, or of any other law passed, or to be passed, by Congress for the benefit of American labor at home, to labor on the Isthmus, is a serious error. Over 80% of the employees of the canal will be aliens. A majority of the other 20% employed will be in a clerical or supervisory capacity. The application of these laws on the Isthmus will benefit a very small number of American laborers but will enormously add to the cost of construction and American labor at home will have to pay its share of the consequent increase in taxation.

In line with this, let me add that Chief Engineer Stevens is preparing three complete sets of plans applicable to as many types of canal, so that when decision shall have been reached as to what type will be used, no delay in beginning work will ensue. It is our confident belief that by the first of July next the plant as purchased will be installed and working to its fullest practical capacity. In other words, by that time the dirt will begin to fly in earnest.

The canal will be built—rest assured of that—and it will be built at Panama. These two phases of the problem have passed irrevocably from the field of debate.

There is an industrious and voluble band of hired Ananiases moving to and fro in the land whose mission it is to deny this. Who is capitalizing this industry? What is the bountiful source of this spouting spring of mendacity? What interests, except those foolishly dreading the competition of an Isthmian Canal, would put up money to delay and possibly defeat its construction? That there are interests of that kind is not a matter of suspicion or speculation, but of history. They have been fighting a canal for more than half a century, and they fought it successfully till Theodore Roosevelt, armed with his "big stick," appeared as its champion. Behind Theodore Roosevelt stand the American people in solid mass and with determined front, shouting as one man: "Give us a canal that will be adequate to meet the demands of the commerce of the world, and give it to us at the earliest possible moment." That, gentlemen, is the command which the Commission, under the inspiring lead of the President, is obeying to the letter.

A DERAILING DEVICE FOR SIDE TRACKS.

The importance of preventing cars or trains on sidings from being accidentally or maliciously moved, or blown by the wind, so as to foul the main track, is now very generally recognized, and numerous derailing devices and stop-blocks are in use to eliminate this danger to trains. The accompanying cut represents a derailing block which is in use on the Union Pacific Ry. and is to be tried on other roads. It consists of a pivoted cast-steel or pressed steel derailing shoe,

Derailing Device for Sidetracks.
T. F. Costello, Grand Island, Neb.

which is operated from the switchstand, the movement of the switch lever moving both the switch and the derail. A special feature of the device, however, is a heavy coiled spring in the rod connecting between the switch and derail. When a train is running onto a switch this enables the brakeman to close the switch and get on the train as soon as the last car has cleared the switch, without waiting for it to clear the derail. The wheels of cars between the switch and derail will then push the latter clear of the rail, as in operating a spring-rail frog. With this device, also, a long train backing into a passing siding cannot be pushed in so far that the rear cars will foul the switch at the other end of the siding. The device is the invention of Mr. C. Mitchell, and is made for him by the American Brakeshoe Co., of Chicago. It is now being handled and put on the market by Mr. T. F. Costello, of Grand Island, Neb.

SETTING OUT AND CHECKING CIRCULAR AND TRANSITION CURVES IN RAILWAY TRACK.

While much mathematical and instrumental work is expended in the laying out of railway curves and in the occasional rectification of these curves, yet the everyday work of maintaining the curves in proper alinement is largely a matter of rule-of-thumb practice, in spite of the important relation of curve alinement to the safe and smooth running of trains. A simple instrument by which the section foreman can readily check the

accuracy of his curves has been designed by Mr. F. A. Smith, Railway Exchange Building, Chicago, and is illustrated in Fig. 1. It consists of an angle bar A, 5 ft. long, at each end of which is a transverse saddle B which rests on the rail head. Over each saddle is a flat seat or rest C, on the upper face of which a removable graduated scale D (at right angles to the rail) is fitted when the instrument is in use. The saddles B are so spaced that the instrument can also be used as a track gage. At the center of the bar is riveted a casting E, having a bearing F for two grooved collars G, G, to which are attached the ends of measuring wires of No. 22 copper wire. When not in use, the wires are coiled on a 3½-in. grooved wheel H, with frame and handle. To the free end of each wire is attached a scale J, which is graduated for curves up to 24° and has a sliding piece or rider K, which is adjusted to the exact length of chord. The instrument is made to measure 25-ft. chords. Through this attachment passes the pin L.

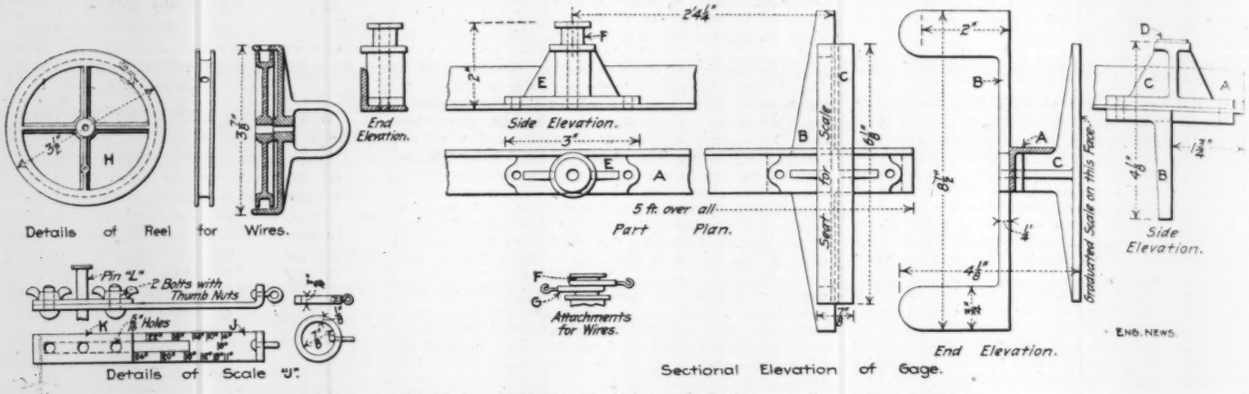


FIG. 1. GAGE FOR LINING AND CHECKING CURVES IN RAILWAY TRACK.

LINING AND SETTING OUT CURVES.—The operation for lining curves with this instrument is shown in the diagram Fig. 2. A stake is driven in the middle of the track at the point of curve A and another at B, 25 ft. back on the tangent. The man with instrument places it with the center point over the center of the first stake A, and the rear man sets the pin at the end of his wire over the center of the rear stake B. The instrument man then shifts the bar until the rear wire is over the center mark on the scale at the rear end (when the bar will be parallel with the tangent), and lines in the front man until the front wire crosses the mark of the given degree of curve on the scale at the front end of the bar. The front man then drives a tack at this point C, either in a stake or on a tie, and the three men move forward 25 ft. With the instrument at C, and the rear end of the wire at A (point of curve),

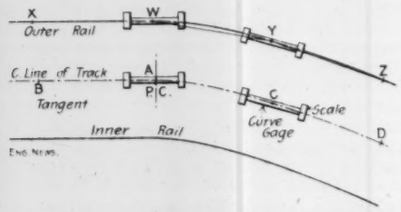


Fig. 2. Diagram Showing the Methods of Using the Curve Gage.

the instrument is swung until the center mark on the rear scale is in line with the wire, and the front man is then lined in until his wire crosses the front scale again at the mark of the given degree of curve. The operation is repeated around the curve, and gives center marks at 25 ft. intervals.

CHECKING CURVES.—To tell whether a curve is in proper and uniform alinement, the instrument is placed on the outer rail of the curve with its center pin against the gage side of the rail head opposite the point of curve, as at W, Fig. 2, while the front and rear men also place the pins at the ends of the wires against the gage side of the rail head, as at X and Y. The instrument is set parallel with the tangent by bringing the rear wire over the center of the scale at the rear end, and the graduation at which the front wire then crosses the front scale is noted, showing the degree of curve. The instrument is then shifted to Y, with the ends of the wires at W and Z. The bar is swung until the rear wire crosses the center mark on the rear scale, and the graduation at which the front wire crosses the front scale is again noted. This operation is repeated around the curve. The graduation shown by the front wire will be the same at each point if the curve is true. Otherwise the several readings are added together and the sum is divided by the number of readings, which gives the proper degree for the curve, and to which it must be adjusted.

TRANSITION CURVES.—Where easement or transition curves are used it is a difficult matter for the trackmen to check or adjust their alinement, but this is rendered much simpler by the instrument above described in connection with a table of offsets.

For laying out transition curves on the track to fit existing circular curves, Mr. Smith employs the following method. The arc B A in Fig. 3 represents a 5° circular curve with P C at A, for which a transition curve is to be laid out. The length of this curve is to be 300 ft., which gives 12 chords of 25 ft., six of these being opposite the curve and six opposite the tangent. A 6° curve inside the main curve is assumed, as shown by the arc B E, the length being 150 ft. and center angle 9°, which gives an arc of 180 ft. The point of circular curve, B, is found by measuring 180 ft. from A on the 5° curve, and the tangent B T staked out. Six 25-ft. chords are then staked out on the 6° curve to the P C at E, with tangent E F parallel with the track tangent H A. The perpendicular H E is bisected at M, the point M being the middle of transition curve, and H M the offset. The point H is fixed on the tangent of the 5° curve, and from it are measured six 25-ft. chords to S, which will be the P C of the transition curve. Divide the length of offset H M (in inches) by 216 and measure off as ordinates: once this amount at 5, 8 times the amount at 4, 27 times the amount at 3, 64 times the amount at 2, and 125 times the amount at 1. Starting again from E (on the 6° curve) measure off similar ordinates; that at 6 equal to that at 1; at 7 the same as 2, and so on to B, the P C C, where the transition curve merges into the circular curve. Stakes and tacks are driven at the ends of these ordinates and mark the line of the transition curve, which is shown by the line S M B in Fig. 3.

It will be seen that for the use of the trackmen no formulas are given, but the mathematical analysis of this method is given by Mr. Smith as follows:

In Fig. 3, let A be the P C of the original circular curve of radius A C = R. Let E be the P C of the inner curve, of radius E D = r. Let B T be the common tangent from B, and the angle B D E equal to the angle B C A = X. Draw D G normal to A C, then C G = D C cos X. But D C = R − r; hence C G = (R − r) cos X. C F = D E = r; and A C − (F G + C G) = offset A F = H E:

$$A F = R - r - (R - r) \cos X = (R - r)(1 - \cos X) \quad (1)$$

$$D G = E F = H A = (R - r) \sin X \quad (1\frac{1}{2})$$

Angle Y is found as follows:

$$\text{Tan } Y = E F \div C F = (R - r) \sin X \div R - (R - r)(1 - \cos X) \quad (2)$$

Length of arc B L = $\pi R (X - Y) \div 180 = 0.01745 R (X - Y)$

Length of arc B E = $\pi r X \div 180 = 0.01745 r X$

Subtracting equation (4) from (3) gives the difference in length of the two arcs: hence

$$B L - B E = 0.01745 [R (X - Y) - r X]$$

If the radii (or the degrees) of the two curves are known and the offset n = H E, the angle X can be obtained from equation (1), thus:

$$\text{Cos } X = (R - r - n) \div (R - r)$$

Since the spiral passes through the middle of H A at M, and joins the old curve at B; the point M is the middle of the spiral, and the length M B is half the length of the spiral. As the difference in length between B E and B L is slight, the length of M B may be taken as equal to either of these in fixing the point S; or it will be better to take it as equal to half the sum of B L and B E.

Since A (the P C) is fixed, M is found by measuring A H along the main tangent, and measuring H M perpendicular to A H: H M = half the offset H E. Then from point H to the right, measure H S equal to B E, and S will be the point of spiral.

To illustrate this by an example, suppose that the end of a 5° curve is to be spiraled as in Fig. 3. The curvature at B would be increased to 6°, and the angle X fixed at (say) 9°, which would make the arc B E equal to 150 ft., or six chords of 25 ft. The length of arc A B would then be

$$0.01745 \times 1146 \times 9 = 180 \text{ ft.}$$

Measure from A a length of 180 ft. on the old 5° curve which fixes the P C C at B, and stake the tangent B T. Place the Smith curve gage at B, and stake out six 25 ft. chords of a 6° curve in the way already described, and ending with the tangent E F parallel with H A, which can be checked by measurement. The offset E H may then be checked by formula (1), and substituting values for the problem we have:

$$(1146 - 955.3)(1 - 0.98769) = 190.7 \times 0.01231 = 2.347 \text{ ft.} = 28.164 \text{ ins.}$$

Half of this (14.082 ins.) gives the point M, which is the central point of the spiral. Beginning at H (as before at B) measure and stake out six 25 ft. chords on the

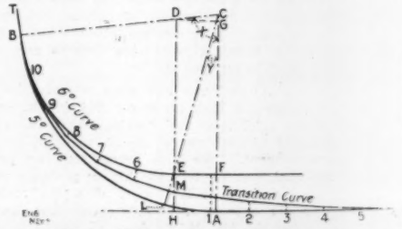


Fig. 3. Diagram of Transition Curve.

tangent to point S. According to the law of the cubic parabola the ordinates at these points are easily determined. As there are six of them, the first (at point 5) would be equal to:

Ord. at (5) =	14.082÷6³ or 14.082÷216 = 0.0652 in., or	1/16
" (4) =	0.0652 × 8 =	1/2
" (3) =	0.0652 × 27 =	1¾
" (2) =	0.0652 × 64 =	4 1/16
" (1) =	0.0652 × 125 =	8 1/8
" (1) =	0.0652 × 216 =	14 1/16

Between M and B, the spiral is located in the same way, the ordinates at points 6, 7, 8, 9 and 10 being equal to those at 1, 2, 3, 4 and 5 respectively. These distances must be measured carefully opposite points on the curve, and a good way to do this is to stretch a light string or thread of cotton from B to E, touching the points 6 to 10, so as to facilitate the measuring of the ordinates.

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Perhaps the greatest difficulty with which the Panama Canal work has had to contend during the past six months has been the glut of freight at the Colon terminal, due to the insufficient facilities at that point for handling traffic. A very interesting part of Mr. Shonts' speech, printed in this issue, is his statement of what has been accomplished to remedy this condition. It would appear that the facilities are now available to promptly care for and forward the materials and supplies necessary for the canal work; and every engineer will understand how important this is to its orderly and economical conduct.

We are enabled to supplement Mr. Shonts' statement with the following letter, written to Mr. Shonts by Chief Engineer Stevens, under date of Oct. 30.

> I spent yesterday (Sunday) at Colon, going through the dock and freight situation both there and on the railroad, and I am exceedingly well pleased at the improved conditions which are everywhere manifested in the freight situation.
>
> I have never seen the docks so well cleaned up, nor the entire business, in the receiving and transferring of local and through freight, in such good condition. The good effect of the demurrage after 48 hours of $5 per day, which we put in force some time since in Panama and Colon, is already manifested, and instead of local merchants at those points using our limited dock and station facilities for storage purposes, they are now arriving at the understanding that this policy will not be permitted and are making steady improvement towards taking care of their own freight, as they should.
>
> The Pacific Mail Steamer "City of Peking" left La Boca to-day with a full cargo. The loading of the "Aztec" is progressing finely, and unless we are handicapped by lack of labor through Fiesta week she will get away in a few days, and her departure will clean up all of the accumulation of freight for Central America, Mexico and northern ports, which resulted from the recent quarantine regulations. At the same time the freight for South American ports is in a normal condition, as in fact it has always been.

The performance of municipal work by municipal forces instead of by the contract system, is a policy which has been followed by the city of Winnipeg, Canada, for several years, and during a recent visit to that city we were informed by the City Engineer that fully 95% of this work is done by the city itself, with most satisfactory results. In connection with this, there is of course a certain amount of municipal ownership. Like most other large cities, Winnipeg owns its water supply system, and in connection with this it also operates a water-softening plant. It also does its own trenching and pipe-laying, having a cableway for this work; and it is now sinking the wells for an additional water supply. The large new concrete storage reservoir is being built by contract, but in order to expedite the work in an endeavor to have it completed before cold weather, the city sent out to the reservoir a concrete mixing plant generally employed on street construction work. The city is also building a high-pressure fire-protection water supply system, with about three miles of distribution mains, and taking water from the Red River. The city does all its street work, both construction and repair, and for this purpose has not only concrete-mixing machinery and other apparatus, but also a large asphalt plant, as asphalt is very extensively used for streets having heavy traffic as well as in residence districts. In connection with the residence streets, the city also takes care of the grass strips or "boulevards" between the curb and sidewalk. Where this is left to the residents or property-owners there is apt to be great lack of uniformity, and the strip may be neglected or very unsightly where the people are careless or the houses or lots are vacant. The city builds its own sewers, and has a trenching machine (with long trestle spanning a length of trench) for this work. For the manholes, annular concrete blocks are used, and these are made at the city's yards. A quarry for block and concrete stone is owned and operated by the city, as is also a garbage crematory. A short time ago it was proposed to establish municipal gas works, but the proposition resulted in such a reduction of rates by the gas company that no definite steps have been taken and the matter is held in abeyance. The city is now proposing, however, to establish a municipal water power plant to generate electricity for lighting and power purposes. The lack of cheap power is a drawback for manufacturing plants, and the intention is to sell surplus power at very little above cost of production in order to encourage the establishment of manufacturing enterprises. It may be noted here that in Winnipeg wood is largely used for both domestic and boiler fuel. The water power plant would be on the Winnipeg River, 60 or 70 miles distant, and as the city's charter does not permit it to undertake work outside of its own limits, a citizens' "association" has been organized to build the plant and transmission line as a construction company, and then turn them over to the city for operation.

Annual guarantees are coming into general use by contractors bidding on Government work for the War or Navy Department in lieu of filing certified checks with every bid. The certified check ties up funds, often for a considerable time until decision on the award of a contract is made, and without any benefit to the bidder in case he does not receive the award. In place of this a contractor may file with the Department on whose work he proposes to bid, a guarantee executed by a responsible bonding company that in case any of his proposals made during the year are accepted, he will within ten days after notification execute the contract to perform the work and give satisfactory sureties therefor.

Such annual guarantees are not only of advantage to the contractor, but they simplify the work of the Government officials, who are relieved of the responsibilities of caring for a number of certified checks and seeing them returned to their owners after every letting.

The Cuban Government has recently been responsible for a very strange proceeding in the letting of a large contract for pumping machinery for the Palatino Pumping Station, in the suburbs of Havana.

Advertisements were issued Aug. 19 last inviting contractors to submit bids for pumps of 5,000 gallons per minute capacity, internal combustion engines to furnish the power and suction gas producers. Bidders were required to submit with their proposals extensive drawings and detail specifications describing the machines it was proposed to furnish. The advertisement stated that bids would be publicly opened at 2 p. m., Oct. 18, by a commission made up of the Director-General of the Department of Public Works, the Chief Engineer of Havana and the Attorney of the Department. Copies of the invitation to bid, with the specifications, were translated into English, and sent to several contracting firms in the United States.

One of the firms undertaking to bid on this contract was Messrs. Bellman & Sanford, of 149 Broadway, New York City. A large amount of work was expended by them in preparing the necessary data, plans, etc., with the intention to bid in good faith for the contract. When this work was far advanced, on Oct. 6, the contractors received official notice that the work would be readvertised, and this was followed ten days later by the announcement that the contract had been let to a firm of Havana contractors on Oct. 11, a full week before the advertised date of letting.

We are not stating the case any too strongly when we say that such action is nothing short of a fraud upon honest contractors acting in good faith. The public invitation to bidders acts at once as a bar to the letting of a contract privately. The contractor who spends time and money in the preparation of a bid does so on the strength of an implied promise that his bid will receive fair consideration when it is offered, and he is defrauded of his just dues if after all his expenditure in preparing the bids asked for he is denied even the chance to present it.

In view of the patent injustice of the action by the Public Works Department, Messrs. Bellman & Sanford immediately cabled a formal protest to the President of the Cuban Republic, Hon. T. Estrada Palma, which was supplemented by protests from: The Power & Mining Machinery Co., Henry R. Worthington and Goulds Manufacturing Co., whose apparatus was to be offered by Bellman & Sanford as fully meeting the exceptionally exacting specifications. In response they received, under date of Nov. 3, a letter from the Secretary of the Department of Public Works, which we print in full as follows:

> Your letter of the 27th ult. addressed to the President, inviting attention to another of the 17th, protesting against the awarding of the contract for the Palatino Pumping Station, has been referred to this office.
>
> In reply I beg to state that said contract was awarded to the firm of Hempel & Co. in conformity with the provisions of the regulations for the government of the Department of Public Works (Order No. 220), as it was considered most advantageous to the interests of the Government to have pumps furnished by said firm that had already been tried by the department and proved in every way satisfactory.
>
> In view of the facts, this office does not consider that any grounds exist for protest.

With all due respect to the officers of the Department of Public Works, we are obliged to say that this is the sort of explanation that does not explain. If the Cuban Government wishes to let a contract to a particular bidder without competition for any reason or for no reason, it has an undoubted right to do so, provided Cuban citizens and taxpayers are willing. But the time to let contracts privately is before inviting other contractors to submit bids and not afterwards.

It appears to us, moreover, that in this matter the reputation of the Cuban Government for good faith and honest dealing is at stake. Whatever the motives may have been for making the above award, contractors are certain to put an unfavorable interpretation upon it. The occurrence will practically act as a warning to contractors that they cannot risk money in bidding on Cuban public contracts except with the aid of political or personal influence or a large allowance for graft. We hesitate to believe that this was the intention of the Havana authorities. They have too much at stake to permit such a reputation concerning the character of their Government to spread abroad in the United States. We prefer to think that the Department of Public Works has acted in this matter in ignorance of the important precedent which it was establishing and the results which are certain to grow out of it; and that, on due consideration, it will rescind its recent action.

REFLECTIONS ON SEWAGE FARMING SUGGESTED BY EXPERIENCES AT READING, ENGLAND.

Sewage farming is practised so little in the United States that the success or failure of that method of sewage treatment in other countries may at first thought seem to be chiefly of academic interest. There are, however, a few sewage farms in the Far West and we have long held that there might well be more. Other reasons for taking note of sewage farming abroad will be mentioned later.

Of the many sewage farms in England that at Reading is one of the largest, comprising a total of 800 acres. The Reading farm was one of a half dozen or so in Great Britain visited a little more than a year ago by a member of the editorial staff of this journal. It bore evidence of

careful and intelligent management, but of poor selection of some of the land, thirty years ago, and of misdirected efforts in certain directions, particularly in horse breeding. The records also showed that for some years the farm had been run at a loss and that this loss had been carried on the books from year to year, instead of charging it off as the net cost of sewage disposal. In other words, the authorities stuck to the fallacy that sewage farming should produce a net revenue instead of merely being a means of lessening the cost of inoffensive sewage disposal.

Early in the present year a report on the operations of the Reading sewage farm was made to the Farm Committee of the Reading Council by Messrs. Arthur A. Avis, Manager of the Nottingham Sewage Farm, S. W. Farmer, who is a farmer in fact as well as name, and Lieut.-Col. Alfred S. Jones, V. C., Assoc. M. Inst. C. E., who has charge, in behalf of the War Department, of the Aldershot Camp Sewage Farm. The report throws no little light on some aspects of British sewage farming, at the same time reflecting the opinion of two of the best known and most able sewage farm managers in Great Britain.

Before giving further consideration to the report we wish to make some reflections designed to show that all England has not yet run wild over septic tanks, contact beds and percolating filters. We do not say this in disparagement of those methods of sewage treatment, as adapted to conditions either abroad or at home, but solely in the interests of better information and more conservative action in America. The septic tank in particular has fastened upon the American public mind, and even upon the minds of some of our engineers, as being a veritable sewage panacea. Well informed persons know that it is only a partial means of sewage purification, and one that still presents some problems for solution: a method excellent in its place, and sometimes fulfilling all present local demands for sewage treatment, but giving a variety of results with a diversity of conditions and by no means doing away with all sludge or rendering the sludge residue always pleasant to handle. Contact beds and percolating filters have their limitations, also. In England, itself, their very birthplace, contact beds have but recently been declared "unscientific," and that seeming too weak a condemnation the speaker added almost in the same breath that they were "dead" (see pp. 411 and 413, Eng. News, Oct. 19, 1905). Other instances might be cited to show that not only is all England not wild over the newer processes of sewage treatment but also that not all England is agreed on the relative merits of the various new processes. Even chemical precipitation is continued without concern in many English as well as some American cities. As intimated at the beginning of this article, many sewage farms are still in use in England, and, it may be added, with no apparent intention of abandonment. Some of them, like the ones at Reading and Nottingham, employ no preliminary processes of treatment. Others, like the large Leicester farm with its stiff, dense clay, have settling tanks and propose to relieve the land still further by providing larger tanks and single contact beds; still others, like the one at Birmingham, are giving even more relief to the land than is proposed at Leicester, while still again some small and long over-burdened land areas, like that formerly serving Aldershot town, have been abandoned wholly in favor of rapid filtration.

In view of the foregoing facts anyone wishing to keep broadly informed regarding present sewage works practise can scarcely fail to be interested in the Reading report. Persons with a much narrower outlook may well be interested in certain phases of the report, in view of the fact that sewage farming is already practiced in the Far West to a limited extent and that the possibilities of sewage irrigation, for the sake of water conservation, deserve careful attention by farmers and economists alike.

Taking up in their order such points in the Reading report as promise to be instructive to some of our readers we note first of all that the percentage of acreage under actual sewage irrigation is smaller than might be expected by one not already familiar with the fact that the exigencies of land purchase and of farming operations generally make it necessary to have a sewage farm embrace a considerable area not available for the application of sewage. At Reading, 102 of the 869 acres are taken up with "allotments, roads, brooks, buildings, etc.," and about 140 acres more are above the level of the sewer outlet. This leaves 627 acres, or 1 acre to 112 population, available for sewage irrigation. Of this, 423 acres actually receive sewage, or in other words there is 1 acre to 180 persons. It appears from the report and the accompanying comments of the Chairman of the Farm Committee, Mr. W. M. Colebrook, that some of the land has been "sewage sick" in the past, through defective underdrainage due largely to a high water table not readily lowered, to very wet weather, and to other local conditions which, like the remedies suggested, are chiefly local and need not be considered here.

Possible septic action in a long outfall sewer is mentioned in the report as a reason for keeping the sewage in motion until absorbed by the land, thus preventing ponding and consequent odors. This septic action in the outfall, combined with the breaking down of solid matters by pumping, doubtless contributes somewhat to the ease of operating the farm without any of the ordinary means of preliminary treatment. Such possibilities may very properly be considered in laying out sewage works.

In discussing the commercial aspects of the Reading sewage farm the authors of the report first commend the "Farm Steward [Mr. Thomas Chettle] and his staff" for their zeal and energy in managing the farm. They then analyze the horse breeding accounts and show an average apparent profit on this score of some $1,600 a year for the five years ending with 1902-3, and about $1,500 for the year 1903-4, but the latter item, at least, contains no allowance for "keep and attendance of brood mares, stallions and colts." It appears, from the Reading accounts and from those of other British cities that have come to our notice, that defective municipal accounting is by no means limited to the United States. There were 74 horses on the farm on March 31, 1903, and 72 horses a year later. Some were used for farm work, but the report states that "before the purchase of steam tackle, the steward estimated that 35 horses could do the work on the farm." Steam tackle, it should be understood, means steam plows and the like, which are commonly employed on large British sewage farms.

Milk production at Reading seems to have declined in order that horse breeding might be practiced. Thus, in 1886, there were on the farm 23 horses and 456 cattle, and in 1904, 72 horses and 242 cattle.

An examination of the whole financial operations of the sewage farm for the past 21 years showed that the accounts had been "so largely affected by the item 'horse hire,' under arrangement with the Highways Committee," that a detailed examination of the accounts with reference to present conditions and management did not seem to the committee worth while. This is another reflection on British municipal accounting which we merely note in passing. As to total yearly results Mr. Farmer, in an individual memorandum, states that of the eleven years ending March 31, 1894, seven showed book profits and four showed book losses, but for the ten years ending March 31, 1904, a book profit was shown for the single year 1889-90, only. The net book profit for the first eleven years is given as £100 and the losses as £14,029, leaving a net book loss for 21 years of £13,029, or about $68,000. Distributed over 21 years, this is an apparent loss of about $3,200 a year. The actual loss must be increased, Mr. Farmer states, by £800 a year for land rent and £500 a year on a capital of £12,000 invested in tools, thus nearly doubling the annual loss shown by the books.

Some $6,000 to $6,500 a year as the average net cost of sewage disposal for ten years (the loss being practically all during the past ten years) does not seem a very bad showing on its face for a town now having a population of about 72,000. But compared with a net book profit of about $10 a year for the preceding eleven years, having, by a proper system of accounting, only capital charges on land and equipment to be debited to the farm, the recent showing appears bad indeed. How much of it is due to lack of judgment or poor management and how much to changed agricultural conditions we cannot say, as the report is silent on the latter point. That the opinion of the committee mistakes have been made is apparent from its recommended changes, given below.

It appears to us as possible that the book profits shown during the earlier or eleven-year period were partly derived from the portion of the farm operated solely as such; that is, without the application of sewage. Mr. Farmer, in his separate opinion, however, seems to hold that the municipal farming operations should be confined to the area needed for sewage treatment, and that the remainder of the land should be rented out. This indicates that in his opinion the extra farming operations are a financial disadvantage. Very likely he is right, but possibly that sort of loss cannot be avoided. The two other members of the committee think Mr. Farmer's solution or simplification of the financial problem impracticable, and that the inherent loss due to the net cost of sewage disposal is the larger part of the total loss. The Farm Committee and Farm Bailiff also appear to think that all or the major part of the land is essential to well-balanced operations on the area required for sewage disposal and that in any event more land will soon be required to care for the sewage.

Anyone familiar with municipal land-purchasing operations knows that when large areas are required, and particularly when provision must be made for increased future needs, some undesirable and perhaps unusable areas must be bought. It requires a high degree of managerial ability to make such areas self-supporting. Sometimes it is far better to stand the capital charges than to run a risk of not making operating expenses in attempts to get a revenue from such land. As a rule, however, a judicious management will find some way of reducing the carrying charges, on all parts of the land area, but this cannot be done with much promise of uniform success unless there is a better system of municipal accounting than prevails in some British and American cities.

Towards the close of its report the Committee sums up the most promising means of diminishing future losses, which losses it fears "are inseparable from your sewage farming." These contain many suggestions regarding what to do and what not to do at Reading, some of which, with intelligent allowances for variations in local conditions, are equally applicable to sewage farms in general. We therefore quote the recommendations, as follows:

(1) Extension of irrigation to grass land.
(2) Reversion to the practice of supplying grass, hay, corn and straw, carrots, etc., required for consumption by the Highways Committee's horses as far as possible from the produce of your sewage farm, all such being charged at fair market or contract rates.
(3) Reform the herd of cattle as follows: (a) The dairy to consist of heavy milkers after third or fourth calf bought in and sold out fat when dry. (b) Young stock bought when required to consume surplus farm produce.

Our argument for a reduction in the extensive system of horse and cattle breeding is that a sewage farm manager should concentrate his attention on the proper distribution of the sewage and upon rapid disposal of the large crops resulting therefrom; also because the manurial return derived from cake and corn fed to young stock on an ordinary farm cannot be realized where abundant manure comes to the land in the form of sewage.

(4) Discontinue market gardening.
(5) Every effort should be made to sell green Italian rye grass, mangolds and farmyard manure at a reasonable price, because it is a well-known fact that they can be produced by sewage on such land as yours in such abundance that—given a ready market for that raw material—you can afford to sell at extremely low wholesale rates. And we are not satisfied that the management of the Manor Farm has sufficiently advertised the excellent quality of its goods and the advantage which horse and cow keepers of the district might derive from dealing with it on easy terms.

Regarding the production of milk the committee says:

We look upon the dairy as a permanent standby of regular consumption, because milk is always saleable, and can be produced almost exclusively from farm produce.

The recommendations and opinions just quoted need no further comment than has been given in

the preceding discussion. It may be noted that the Farm Committee, in submitting the report to the Reading Council, disagreed with recommendation (3a), arguing that the buying in of "heavy milkers after the third or fourth calf" and selling them "out when fat and dry" is not in accordance with "the practice of most successful dairy farmers." Nevertheless, the Farm Committee stated that it would experiment in a small way along that line.

One other part of the report is worth mentioning. The examining committee suggested that "the wages bill must be very carefully considered" and pointed out that for the four years ending March 31, 1903, an average of £3,430, or nearly $17,000, had been paid for wages, amounting to about $19 an acre. When our editorial representative visited the farm in 1904 he was told by Mr. Chettle that an average of 70 men and boys were employed there, running to 100 at harvest time. The regular weekly wage was 16 shillings, or $3.89, besides house and garden and an extra cash payment of 80 shillings or $19.44 at Michaelmas (Sept. 29; a feast day and quarter-year rent day). The working hours were from 7 a. m. to 5 p. m. in winter and from 6 a. m. to 5.30 p. m. in summer. There were then 23 cottages on the farm, forming a part of its equipment.

The figures in the foregoing paragraph will be of interest to anyone who wishes to consider sewage farming in connection with the municipal labor problem in the United States. Considering these figures in connection with the land areas involved and the farm and commercial management necessary in the production and sale of large quantities of farm and dairy produce, there results a picture not very encouraging to the extension of sewage farming in the United States. Our heavy consumption and waste of water would require larger per capita sewage farm areas than are necessary in Great Britain. This fact, together with short hours and high wages for municipal labor, would raise the wages bill to a high figure, even if dependence could be put on getting a fair day's work from men appointed under the party government system. The same party system makes very uncertain indeed the selection and retention of fit men for sewage farm managers and foremen.

But although there seems to be no present outlook for ordinary sewage farming in this country we still believe, as we have for many years, in the possibilities of using sewage for irrigation in the arid and semi-arid West. Some progress in that direction has already been made and more is bound to follow.

Another possibility is the utilization of sewage by truck gardeners in other parts of the country than the waterless West; chiefly, but perhaps not wholly, as a safeguard against occasional droughts. This would involve practically no increase in municipal employees or expenditures and might make some notable additions to municipal income.

The septic tank bids fair to be a useful adjunct to the extension of sewage utilization on land, making available the plant food in the sewage while at the same time lessening the clogging materials sent to the land. But its use must be attended with great care to ensure a septic effluent as free as possible from odors, and great pains must be taken, as suggested in the Reading report, to ensure so perfect a distribution of the sewage that there will be no ponding.

In conclusion, we wish we might bring home to American municipalities the need of placing and keeping their sewage works, regardless of the method of treatment, in the hands of trained managers and workmen; the managers to be chosen, so far as practicable, from men trained in the technical schools; the workmen to be selected on the basis of general intelligence and adaptability to their tasks; and both managers and workmen to be retained when once they have gained experience, instead of being footballs of party politics. When such conditions are fulfilled we in the United States will be free to choose methods of sewage treatment wholly in accordance with their evident fitness to natural conditions, instead of having the managerial and labor problems the ruling factors in our choice, with nine chances out of ten of failure, regardless of system, through grossly improper operation. It is possible that with the best of management assured sewage farming would rarely be desirable in this country, but a removal of one of the chief obstacles to its adoption would be welcomed by many engineers, particularly since, besides giving them a greater possible range of methods to choose from, it would also go far towards assuring the success of any well-chosen method of sewage treatment.

LETTERS TO THE EDITOR.

A Problem in Improving Railway Location.

Sir: In the letter from Mr. W. W. Urquhart, in the Engineering News of Oct. 26th, the method of calculating the line L P, which is the key to the problem, is ingenious but somewhat roundabout.

By calculating coordinates of the points L and P from true or assumed bearings, and closing between them, the length and bearing can be found much more readily. This would not only reduce the work, perhaps 90%, but by simplifying it would reduce the chance of error.

Respectfully, Chas. E. Bengler.

577 Telegraph Ave., Oakland, Calif., Nov. 1, 1905.

The Responsibility for Errors in Surveys.

Sir: In reply to "B. S. R.," of Guthrie, Okla., with respect to the responsibility of city engineers or county surveyors for errors, I would say that they are liable civilly for the full amount of loss or damage occasioned by their mistakes: provided, however, that the error was one in workmanship and not an error in determining a legal question of conflicting rights.

A form for "Certificate of Survey" need merely state that the signer certifies that he has made a survey of such and such premises, staking same on the ground, or plotting same, as the case may be.

Yours truly, William E. Kern.

3325 North Park Ave., Philadelphia, Nov. 11, 1905.

More Concerning the Record of Charles de Nevers.

Sir: In the issue of Engineering News of Nov. 9 you have a short notice in the personal column concerning one Charles Francis alias Chas. de Nevers. It may interest you to know that in 1903 this man appeared in London where he obtained money on bogus checks from a number of persons, among whom the writer was one. He also then represented himself to be a M. Am. Soc. C. E., M. Inst. C. E., Doctor of Science, etc., and he also carried the badge of the Legion of Honor. In September of that year he was convicted on several charges and was sentenced to serve a term of 1½ years in prison.

Yours truly, A. Jordahl.

Carnegie, Pa., Nov. 10, 1905.

Some Results of Geological Survey Work in the Location of Underground Waters.

Sir: In the issue of your magazine, Vol. 52, pp. 111-112, 1904, you commented favorably on the methods of work of Mr. W. H. Norton on the underground waters at Waterloo, Iowa, and contrasted them with the divining rod scheme such as had been recently reported in England.

It may be of interest to know that the predictions made by Mr. Norton, who was working under my direction for the Eastern Section of Hydrology, U. S. Geological Survey, were fulfilled almost exactly by the results obtained when the well was actually sunk. For instance, he estimated that the St. Peter sandstone would be encountered at 835 ft.; the well actually encountered it at 840 ft. The top of the Jordan sand was estimated at 1,315 ft. and was found at 1,360 ft. The estimated head was 20 to 30 ft.; actual head, 20 ft. The capacity was estimated probably not to much exceed 200 gallons per minute, while the actual test of the 8-in. well showed 200 gallons per minute.

This is one of the numerous instances of a practical application of artesian principles as they are now applied by the Eastern Section of the Division of Hydrology, and I believe would be of interest to readers of your journal.

Very truly yours, M. L. Fuller.
Chief Eastern Section Division of Hydrology.

Washington, D. C., Nov. 6, 1905.

Burned and Overheated Rivets; Symptoms and Effects.

Sir: In your issue of Nov. 9 you publish an inquiry which reads "Are Rivets Damaged by Overheating or 'Burning'," in answer to which a very positive Yes may be given. Under this heading nine distinct questions are put which it may be well to answer in detail.

(1) Rivets commonly called "burnt" are such as have been either exposed to an excessively hot fire or have been on the fire for too long a period of time; they are not frequent causes of failures because it is customary practice to discard them.

(2) A rivet which is slightly pitted should certainly be condemned because this is evidence of overheating and injury to the metal.

(3) The signs of a rivet, not yet driven, having been overheated are generally found in pitting on the surface, or the dripping of steel upon removal from the fire.

(4) After overheated rivets have been driven, rough and ragged or even split edges at the heads are evidence of overheating.

(5) It is easily possible to injure the metal of a wrought-iron rivet by overheating in an ordinary portable furnace. Rivets are frequently found burnt at the end when heated carelessly in such furnace. As wrought-iron rivets contain cinder between the layers of the pile, chemical action readily takes place which deteriorates the iron in the rivets.

(6) The sparks emitted by the heated rivet are frequently a sign of overheating and attest that the temperature was sufficiently high to start the metal burning; all such rivets are injured at the burning end and should be rejected.

(7) Rivets which have been reheated several times are likely to have been injured by long exposure to heat and should therefore be rejected.

(8) The principal points to be observed in the heating of field rivets are that they be brought to a bright red heat without showing signs of dripping or sparking and that the head be slightly hotter than the end, and also that they be clean from cinder and rust.

(9) The most common faults in heating field rivets are that the ends are rather hotter than the heads, and that they have not been raised to a sufficiently high temperature, allowing them to cool off too much before they have been driven. Very respectfully,

Gus. C. Henning.

150 Nassau St., New York, N. Y., Nov. 10, 1905.

A Problem in Improving Alinement.

Sir: I have read with great interest the communication of Mr. W. W. Urquhart in Engineering News of Oct. 26, giving a solution of the problem of finding a tangent between the two outside curves of a section of located line containing three curves. It may be of interest to consider the solution of the problem in another way.

Referring to the accompanying sketch, which is lettered to correspond with Mr. Urquhart's as nearly as possible, we have between the points C and D a section of located line; and, on the assumption that the alinement data are

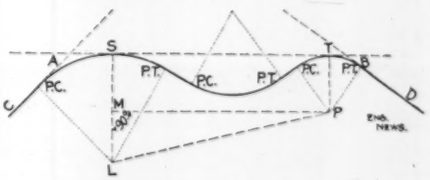


Diagram of Computations for Estimating Curvature.

at hand, we may refer the direction of all tangents to any convenient line of zero azimuth (assumed). Probably the most convenient reference line would be the initial tangent C A, or the final tangent B D. Assume an origin of coordinates on this reference line, and calculate the coordinates of the centers L and P of the two outside curves. Let S T be the tangent whose position is to be determined, S being the new P T of the first curve, and T the new P C of the last curve.

The line M P is drawn through P perpendicular to S L and is therefore parallel to S T.

Assume that the calculated coordinates of L are (x, y) and of P (X, Y). Then the length of

$$L\ P = \sqrt{(x - X)^2 + (y - Y)^2}$$

and the tangent of its azimuth is given by

$$(X - x) \div (Y - y).$$

Since angle M is a right angle, and M L = R − r where R and r are the radii of the first and last curves, respectively, we can now find angle M P L by the relation sin M P L = M L ÷ L P. But, the azimuth of M P (or S T) = azimuth of L P + angle M P L.

This gives us the direction of the new tangent. The new central angle, A, of the revised first curve is equal to: Azimuth of tangent T S — Azimuth of tangent A C. Similarly, the new central angle of the revised last curve is: Azimuth of B D — Azimuth of S T = Angle B. Knowing the central angles, A and B, the necessary data for the revised curves are easily figured.

Yours truly, Robert W. Gay,
Jun. Am. Soc. C. E.

442 Pawnee St., South Bethlehem, Pa., Oct. 27, 1905.

The Relative Activity of Natural and Portland Cements.

Sir: In order to settle a slight discussion, would you mind commenting on the relative time of set between Rosendale and Portland cement? As a young engineer, I contended that Rosendale is the quicker setting, as the text-books say, but I have been informed differently by

two or three engineers who are fortunate enough to be able to abandon their text-books and go by experience.

Respectfully,

"Young Engineer."

Key West, Fla., Sept. 16, 1905.

(Knowledge of the activity of cement is so important in engineering work that a vast number of test data have accumulated on the subject. The comparison of these data leads undeniably to the conclusion of the text-books that natural cements, as a class, are quicker setting than are Portland cements as a class. There are, however, individual cements in both classes which act abnormally, in respect to activity, to the class as a whole. Thus, while the majority of natural cements will begin to set in 20 to 30 minutes, and will set hard in 40 to 60 minutes, there are some which will begin to set in 5 to 10 minutes, and set hard in 15 to 20 minutes; and others (a few of the slowest) which will not begin to set much short of an hour, and will be an hour and a half or more in setting hard. Similar variations are recorded by Portland cements; the majority will not begin to set short of two hours, but some of the most active will begin to set in from 20 to 40 minutes. A very active Portland cement may set much more quickly than a very slow setting natural cement. This, however, does not warrant one in classing Portland cements as more active than natural cements; averaging the time of setting, class by class, we find without question that natural cements are the more active. It is possible so to influence by manipulation or admixture with other substances the activity of hydraulic cements as either to retard or to hasten the time of setting. It is, therefore, assumed in all comparisons of the relative activity of different classes of cement or of different brands of cement of the same class that the test conditions are similar.—Ed.)

A Diagram for T-Beams of Reinforced Concrete.

The diagram shown herewith is believed to be new as regards the slab lines, and is sufficiently correct for most practical purposes. The neutral axis is put at .4h from top, h being the depth from top surface to (single) reinforcement. The stress area taken as partly parabolic, is 7/8 that of a triangle, on account of E_c varying 50% between neutral axis and outside fiber. Rectangular beams, or stems of T-beams, are found on the parabolic curve per foot width of b, and the slab part of T-beams on the lines marked with slab thickness per foot width of (B — b). The areas of steel, also per foot width, are given by the radiating lines.

The slab lines are laid off from the tangent to parabola, beginning on tangent point at h = 2½ t, and falling 4% below tangent at h = 5 t. At 2½ t ($= \frac{t}{.4}$) the bottom of slab reaches neutral axis, as in a beam.

The lines are stopped at 5 t, because thinner slabs require calculations for shear, and because the two values diverge too much beyond; but may be ranged out farther if desired.

Example 1: Span 20 ft., total load 600 lbs. per sq. ft., beams spaced 5 ft., slab 4 ins. thick. Total moment = $600 \times 5 \times 20^2 \times 12 \div 8) = 1{,}800{,}000$ inch-pounds. In diagram, for 1/8 M = 360,000, a beam requires 17 ins. depth; a 4-in. slab 20 ins.; try 18 ins.

18 ins. on curve = 400,000 × (say) 2 ft. = 800,000
4-in. slab = 300,000 × (5 — 2) 3 ft. = 900,000

[1,800,000 Reqd.] 1,700,000

Require $\frac{18}{17}$, or $\frac{1}{17 \times 2} = \frac{1}{34}$ part more depth.

= 18½ ins. (depth counting twice requires half the ratio of moments.)

For steel area; 18½ ins. = 1.7 × 2 ft. = 3.4 (curve)
" = 1.3 × 3 ft. = 3.9 (slab)

7.3 sq. ins.

Example 2: Stem limited to 1 ft. wide, and combined width 3 ft. used out of 5 ft. panel. Moment 1,800,000 ÷ 3 = 600,000 on curve gives 22 ins. depth, or 27 ins. for 5-in. slab.

Try depth 24 ins., curve = 700,000 × 1 ft. = 700,000
" 5-in. slab = 525,000 × 2 ft. = 1,050,000

[1,800,000 Reqd.] 1,750,000

Required $\frac{180}{175} = +\frac{5}{175 \times 2} = \frac{1}{70}$ part more = 24⅓ ins.

Steel 24⅓ ins. (curve) = 2.2⅓ × 1 = 2.25
" " (5-in. slab) = 1.6⅔ × 2 = 3.33

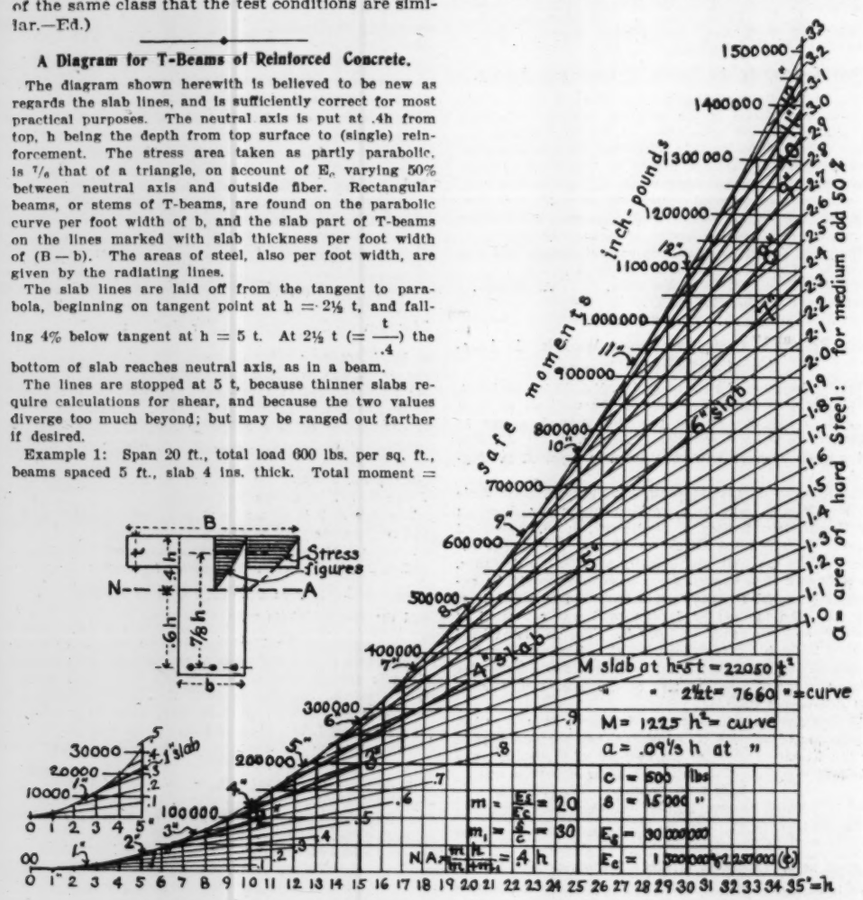
5.58 sq. ins.

Diagrams may be drawn for other constants in a similar manner; the simplest being for: Neutral axis = 0.5 h, triangular stress area, tangent point at h = 2 t, lower line on the tangent itself, arm ⅝ h; drawing an average line a little higher, or two lines if preferred beyond 3 t. Steel area at curve = .1 h.

The rule for taking depth varying as one-half the error of moment, is exact for stem, but only partly true for slab part, hence for great accuracy calculation may be repeated with new depth.

C. E. Young.

1706 Oregon Ave., Washington, D. C., Oct. 12, 1905.

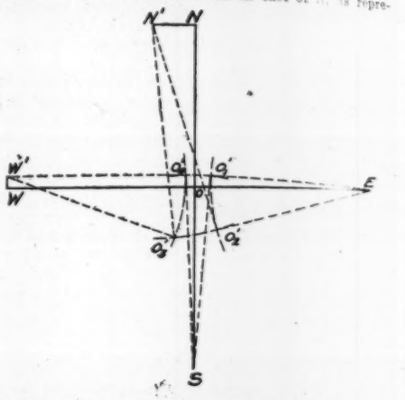


MOMENT CAPACITY OF T-BEAMS OF REINFORC ED CONCRETE.—C. E. YOUNG.

Bending Moments in Inch-Pounds per Foot of Width, and Steel Area in Square Inches per Foot of Width.

Locating a Lost Section Corner Again.

Sir: In your issue of Nov. 2d I note "Panhandle's" criticism of my letter which appeared in your issue of October 12, and I must say that I do not agree with him on some points. He is perfectly correct when he says that, as the recorded government distances are inconsistent, the numerical values given in my letter for the location of the required section corner from the intersection of the random meridian and parallel will not necessarily be the corner sought, as the distances $O_1'E$ and $O_1'G$, or one of them, may easily be in error. In the present case, if the south corner and the distance 80 chains from it are used, there will be found two points about 19 ft. north of the random parallel, one of which is about 52 ft. east of the random meridian and the other about 8 ft. west of it; if the north corner and the distance 80 chains from it are used, there will be found two other points about 550 ft. south of the random parallel, one of which is about 8 ft. west of the random meridian and the other about 52 ft. east of it, as represented in the accompanying figure, which has been somewhat distorted to avoid confusion.



In looking over the data submitted by your correspondent in your issue of Sept. 21, the writer recognized at once that the data were inconsistent, but on account of the fact that they gave possible locations almost 600 ft. apart, corresponding to an impossible error of about one in eight, and as the offset at the north corner was over 900 ft., he immediately came to the conclusion that the data were assumed. On this basis he worked out and presented the best possible method of locating the lost corner from two known corners. The other three corners, O_2', O_3', and O_4', can be located in precisely the same way by applying the same method, slightly altered, to each successive pair of corners, such as N' and E, W' and N', S and W'. Which corner is the correct one is a matter for the surveyor to decide.

The "Manual of Surveying Instructions," published by the Department of the Interior, calls for an accuracy corresponding to an error of not more than 1 in 160 for the error of closure, which, in a mile, is approximately 33 ft. more or less than 5280 ft. Now, assuming that the original work had been done on this basis, it is easy to see that the actual location of the desired corner would lie within a radius of about 33 ft. from any one of the four points found. As a matter of fact, if any trace of the original corner remained such trace could be found very readily by carefully examining the ground immediately surrounding any one of the points located, as described in my letter of Sept. 21. When the discrepancy is as large as in the case under discussion the surveyor must be governed by local conditions. In such a case it would be reasonable for him to assume that one of the outside corners had been incorrectly located, such as the north corner, 941 ft. from the random line, or that one of the distances had been measured or recorded incorrectly. His duty then is to find out which corner is located incorrectly, or which distance is incorrect; for this purpose he should procure, if possible, all the old notes relating to the original survey and retrace them on the ground.

One of the best methods seems to be to follow the government' instructions for the original location of the sectional lines, as the surveyor is then more likely to follow up the original lines than in any other way. On this subject the Manual of Surveying Instructions, Article 135 et seq., says:

> The exterior boundaries of a full township having been properly established so far as possible, the subdivision thereof will be made as follows:
>
> At or near the southeast corner of the township, a true meridian will be determined by Polaris or solar observations . . . ; then from said corner the first mile of the east and south boundaries will be retraced . . .
>
> The meridianal sectional lines will be made parallel to the range line or east boundary of the township by applying to the bearing of the latter a small correction dependent on the latitude . . .
>
> . . . the deputy will commence at the corner to sections 35 and 36 on the south boundary, and run a line parallel to the range line, establishing at 40 chains the quarter section corner between 35 and 36, and at 80 chains the corner for sections 25, 26, 35 and 36.

The method of operation outlined above is repeated for each successive range of sections progressing to the west; it is not necessary to complete the survey of one range before that farther west can be surveyed, the survey can be started at any corner on the south boundary of the township, care being taken that the meridianal sectional line has the proper bearing for that range. Following this line of reasoning to its ultimate conclusion it is possible for the surveyor to replace any lost section corner by going to the next corner south on the same range line, determining the meridian by Polaris or solar observation, and then, correcting the bearing so that his line will be parallel to the range line or east boun-

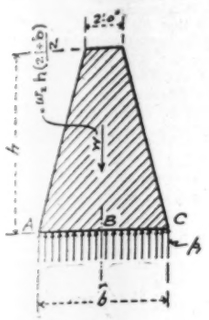


Fig. 1.

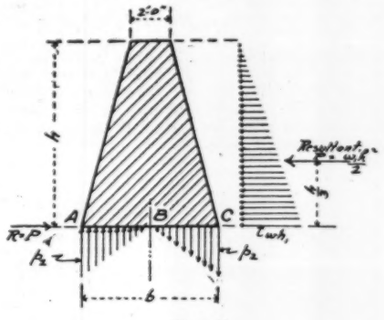


Fig. 2.

dary of the township, proceeding 80 chains north of the known corner to a point which, if the records are correct, the known corner properly located, and the work correctly done, will be the point desired. If by continuing the survey to the next corners north, east, and west in order to establish the lost section lines, it is found that the point located above is not consistent with other dimensions, the surveyor must rely on his own judgment and local evidence as far as possible.

On this latter point the Department of the Interior, in its Manual of 1902, takes the following stand:

> The General Land Office assumes no control or direction over the acts of local or county surveyors in the reestablishment of extinct corners of original surveys, nor will it issue to them instructions in such cases. It follows the general rule that disputes, arising from uncertain or erroneous location of corners, originally established, by the United States Government, are to be settled by the proper local authorities, or by amicable adjustment; and to aid in this result it furnishes a circular pamphlet which the office desires to be considered as merely advisory and explanatory of the principles which should prevail in performing such duties.

The circular mentioned above is entitled "Restoration of Lost and Obliterated Corners, and Subdivision of Sections," and is dated March 14, 1901. The writer advises any one who has anything to do with this class of work to procure a copy of the Manual of 1902, referred to above, and also a copy of the circular, as they will be found of inestimable value.

It may be well at this point to comment on "Panhandle's" statement that "Public land surveying is not an exact science, but consists of a set of arbitrary rules prescribed by the United States Land Office." It is my opinion that public land surveying is as near an exact science as it can be made without making the expense of the same prohibitive. Guide meridians are run by observations on Polaris or solar observations, standard parallels are corrected for curvature. The only part of the work that is arbitrary consists of the distances between guide meridians, and standard parallels. These distances have been chosen arbitrarily as 24 miles; the sizes of townships and sections have also been chosen arbitrarily, as approximately six and one mile square respectively.

The idea that public land surveying, and in a great many cases, private surveying is not an exact science has given rise in the past to a feeling that "everything goes"; this has been the cause of a great deal of mistakes and inaccurate work that could have been avoided and accurately done had the importance been realized. As a result a great part of the work that was done by our ancestors one or two generations ago is now being done over again, and it is safe to say that some of the work that is being done to-day will require to be done over again one or two generations hence.

Every surveyor should exert himself to attain as high a degree of accuracy as is practicable and consistent with economy and speed. Local considerations will of course govern in all cases. It is as absurd for a public land surveyor to attempt to attain an accuracy of 1 in 5,000 in the survey of a worthless tract of land as it is for a surveyor to be satisfied with an accuracy of 1 in 100 in New York City.

1519 Pine St., Charles E. Smith.
Scranton, Pa., Nov. 6, 1905.

Sir: If Chas. E. Smith and Antonio Llano will remember that the U. S. Government provides that in reestablishing lost section corners such corners shall be placed at such distances from known corners that the established distances will bear the same ratio to the original Government distances as the total measured distances between known corners bears to the original Government distances between the same corners, I am sure that they will modify their solutions of Mr. Anderson's problem in surveying which they give in Engineering News of Oct. 12. Mr. Smith will find that Mr. Anderson was not wrong in showing his reestablished corner south of the random parallel and Mr. Llano will be obliged to retract his criticism of Mr. Anderson for measuring through to the next known corners and noting the errors in closing. Both Mr. Smith and Mr. Llano err in attempting to solve this problem by means of the angle between the random lines and in disregarding the through measurements. Mr. Anderson's sketch shows that he understands the problem, which is simply one of erecting perpendiculars at such points on the random lines that the distances from the point of intersection of these perpendiculars to the known corners will be proportional to the original Government distances to the same corners. However, the problem proposed by Mr. Anderson is unusual inasmuch as the desired section corner falls so far out of straight lines between the opposite known corners. This requires trial calculations to determine from the random distances what the measured distances between the known corners would be if the randoms followed the lines of the original survey. If called upon to reestablish this corner, I would place it 4.00 chs. south and 15 lks. east of the intersection of the randoms.

Yours truly, F. A. Steiger.

Vacaville, Solano Co., Cal., Nov. 6, 1905.

The Design of Retaining Walls.

Sir: Commenting on the article in your issue of Aug. 17 by Mr. H. P. Boardman, on "Retaining Walls," I beg to call attention to what seem to me incorrect assumptions made by the author in his theoretical treatment of the problem, namely, (1) That the wall rests on an unyielding base, and (2) That moments be taken about the toe of the wall. This latter assumption is made also by some well known authorities, notably, Trautwine in his Handbook, and Baker in his Masonry Construction, though neither of these authors uses the moment so found in the actual designing of the wall, but rather as a test of its stability. The second assumption is made also, I notice, by Mr. C. F. Graff in an article appearing in Engineering News on March 9, 1905, giving the methods employed in designing a reinforced concrete wall for the Great Northern R. R. at Seattle, Wash.

As a matter of fact the "unyielding base" does not exist, excepting approximately in the case of a wall built on solid rock; and in very few cases would it be proper to take moments about the toe of a wall as ordinarily built, for the reason that this assumes the point of stone representing the toe to be sufficiently strong against crushing to bear the entire weight of the wall, plus some additional pressure due to the lateral thrust. Moreover, even if the base below were unyielding, and both toe and its support below strong enough to bear this concentrated load without crushing, it is likely that the internal stresses so developed would break up the monolithic condition of the masonry involved in this assumption, before the wall could be tilted sufficiently to throw all the load on the toe.

The wall proper could, of course, be designed to meet these assumptions; the former by providing a toe of sufficient strength to receive this concentrated load, with a corresponding support below, and the latter by providing a bond in the masonry sufficient to resist the distortion mentioned; but now the critical point has only been transferred further down, to the joint between the wall and the earth below.

Neither the upper nor the lower surface of the joint, be it between courses of the masonry or between the masonry and the earth below, is unyielding in the sense used in this connection, and the reactions produced by the external forces are not concentrated at any one point, but rather are distributed over the joint, uniformly in the case of a wall acted upon by a single centrally applied force as of its own weight, and of varying intensity under all other conditions of loading.

The designing of a wall to resist by gravity horizontal thrust of any kind, may be divided into two parts, (A) determining the intensity and distribution of the forces acting upon the wall, and (B) designing the wall section to resist these forces. The former, (A), requires the exercise of judgment based on experience and experimenting, coupled with a study of the conditions, actual and possible, that are known to exist or that may exist during the life of the wall, and varying from the clearly defined "liquid pressure" of dams to the uncertain and variable pressure coming upon the ordinary retaining wall. The latter, (B), consists simply in applying the ordinary principles of designing, namely, determining the resulting internal stresses and placing the materials so as to resist same in the most economical manner. The section of wall as finally adopted would naturally be a resultant of local requfrements (such as, for example, the ordinary condition that the exposed face be vertical), and of the forces acting thereon, taking into account the nature of the materials to be used in construction and for backing, etc.

Assuming, for sake of comparison, the same section as that taken by Mr. Boardman in making his calculations; assuming also the same external forces, namely, "liquid pressure" for a substance weighing $w_1 = 50$ lbs. per cu. ft., acting horizontally, and a stability load consisting of the wall weighing $w_2 = 150$ lbs. per cu. ft., acting vertically, the stresses that will develop in any joint may be analyzed as follows, taking the length of wall as one foot:

Dividing, for the sake of simplicity, the reactions produced by the different forces, there will result,

(a) For the load W (see Fig. 1), a uniformly distributed pressure on the joint A—C expressed by the equation,

$$p_1 = w_2 h\left(\frac{2+b}{2b}\right) \quad \ldots\ldots\ldots\ldots (1)$$

(b) For the horizontal force P (see Fig. 2), a horizontal force R acting in the plane of A—C and of amount expressed by the equation,

$$R = P = \frac{w_1 h^2}{2} \quad \ldots\ldots\ldots\ldots (2)$$

together with a couple of distributed forces acting perpendicular to the joint A—C and varying in intensity from zero at the center B uniformly to a maximum of p_2 at A and C, upward on one side and downward on the other as indicated in the sketch. The amount of unit pressure p_2 is determined by taking moments of all external forces about B, the center of gravity of the base, and equating thereto the moment of resistance of the section A—C.

Letting M_1 = moment of external forces about B, and
M_2 = moment of internal resistance of joint about B,

then will $M_1 = \frac{P h}{3} = \frac{w_1 h^3}{6}$

and $M_2 = \frac{p_2 b}{2} \times \frac{2 b}{3} = \frac{p_2 b^2}{6}$

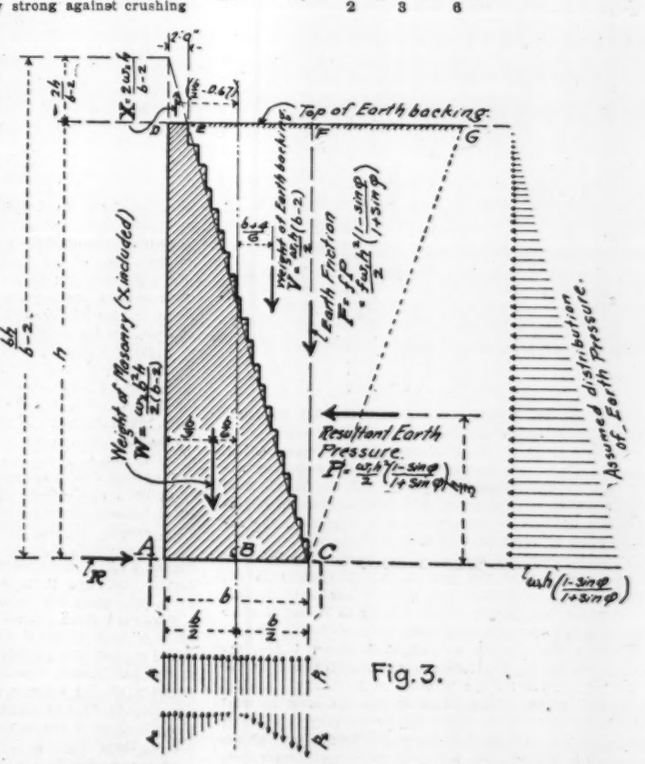


Fig. 3.

Equating these values of M_1 and M_2, and solving for p_2 there follows,

$$p_2 = \frac{w_1 h^2}{b^2} \quad \ldots\ldots\ldots\ldots (3)$$

Having thus derived all the formulas for the reactions

necessary for equilibrium regardless of the construction used, it is now necessary to meet the conditions required by the nature of the construction adopted, which are as follows:

1. For any joint in ordinary masonry, and for the joint between wall and foundation below in any type of con-

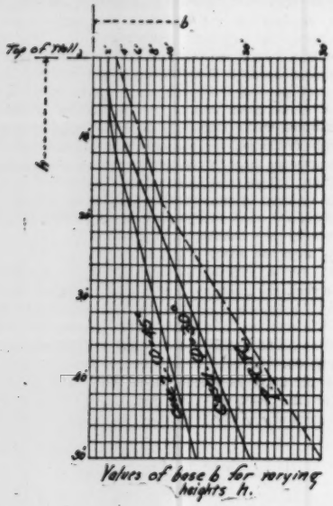


Fig. 4.

struction, no tension is allowable at the point C. This condition is met by the following,

$$p_2 - p_1 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

2. To prevent crushing at the toe A, the total unit pressure here shall not exceed the allowable unit pressure on the joint, which let us call p_0. This condition will be met by the following,

$$p_1 + p_2 = p_0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

3. To prevent the wall from sliding bodily forward, it is necessary that the force R shall not exceed the total friction developed in the joint A—C by the pressure normal to same. This is met by the following,

$$R = f_1 p_1 b \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where f_1 is the coefficient of friction for the masonry on the surface below the joint.

By inserting in equations (4), (5) and (6) the proper values of p_1, p_2, and R given in equations (1), (2) and (3) above, there will be found three distinct values of the width b in terms of the height h corresponding to these three conditions; by adopting the largest value obtained for b, all of these conditions will have been met. Ordinarily the first condition, as expressed in equation (4), will govern for all joints of a masonry wall excepting that between the wall and the earth below, for which all three conditions should be investigated and the footing course spread if necessary.

Solving equation (4) for the case at hand, I have tabulated below the values of b for different heights h, together with the corresponding values given by Mr. Boardman:

	Boardman.		Worthington.		
h, ft.	b, ft.	b/h	b, ft.	b/h	Difference.
5....	1.56	.312	3.2	.640	105% greater.
10....	3.82	.382	7.2	.716	88% "
15....	6.14	.409	11.3	.752	84% "
20....	8.46	.423	15.3	.765	81% "
25....	10.81	.432	19.4	.775	79% "
30....	13.17	.439	23.5	.785	78% "
35....	15.50	.443	27.6	.790	78% "
40....	17.85	.446	31.7	.792	78% "

It will be seen that the values of b and b/h as determined by the method described above are very much larger than those given by Mr. Boardman for the same loading. The conditions that he has assumed for the loading approximate closely those of a dam, and are much more severe than would ordinarily exist in the case of a retaining wall if proper provision is made to prevent the accumulation of water back of it.

Following up the subject I am presenting below a general solution of the problem which appears to me rational and reasonable, and without any hair-splitting refinements that are generally conceded to be out of place when applied to a retaining wall.

Dividing the problem as suggested above, I first assume for the earth pressure a force determined by the Rankine formula for the pressure of loose earth against a vertical plane. This seems to me the most rational of all the various methods for determining the proper thrust of the earth against the wall. By this method the horizontal thrust on a vertical plane where top surface of earth is horizontal is assumed to vary in intensity directly with the depth h, the weight of the earth and the value of $\left(\frac{1-\sin\phi}{1+\sin\phi}\right)$, ϕ being the angle of repose for the earth in question. This condition of loading may not always exist, may in any particular case never exist, but it represents pretty fairly the maximum thrust, and therefore the condition which the wall should be constructed to safely resist or else be in constant risk of failure.

In Fig. 3 is shown a typical section of retaining wall together with the amount and distribution of all forces acting thereon. Assuming that all dimensions given are in feet, weights and forces in pounds, and that all loads, etc., are for a unit length of wall. Also letting,

ϕ = Angle of repose of earth backing.

$f = \tan\phi$ = Coefficient of internal friction of the earth backing.

w_1 = Weight per cu. ft. of earth backing = 80

w_2 = Weight per cu. ft. of wall = 140.

M_x = Moment of external forces about B, the center of gravity of joint A—C.

M_r = Moment of resistance of the joint A—C about same point B.

The assumed external forces are then as follows:

(a) The weight of wall W (including for ease in calculations the small triangular section X) acting downward.

(b) The weight X, to be deducted and therefore taken as acting upward.

(c) The horizontal force P, being the resultant horizontal earth pressure as determined by the Rankine formula, distributed as indicated at the right of the figure (or in any case the horizontal component of the thrust).

(d) The weight V of the triangle of earth resting directly on the inclined back of the wall.

(e) Finally the force F acting downward and representing the earth friction along the vertical plane C—F.

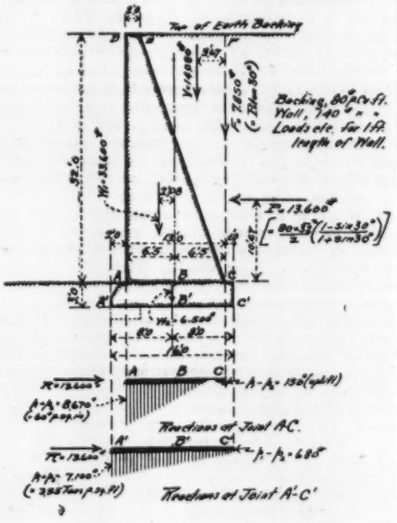

Top of Earth Backing
Backing, 80 lbs. per cu. ft.
Wall, 140 " " "
Loads etc. for 1 ft. length of Wall.
Reactions of Joint A-C.
Reactions of Joint A'-C'

Fig. 5.

This last force F, though generally neglected, is a real one produced by and coexistent with the horizontal thrust P, varying also directly with it. It represents the weight of that body of the backing, indeterminate in amount, which the pressure of the particles horizontally so compacts against the triangular body of backing resting directly on top of the wall, that it practically forms part of same, the horizontal pressure tending to hold this body of backing and that represented by V in place against the wall just as cohesion holds together the particles of stone in the wall itself. Looked at from another view point, suppose the earth backing to be gradually removed from the wall, having first substituted for the horizontal pressure of the particles of earth an imaginary force properly distributed; there will cling to the plane C—F a triangular shaped body of earth about as outlined at C—F—G, held in place by the friction induced between the particles of material by the pressure P. The weight of the material thus overhanging will be the product of the force P by the coefficient of friction f of the material upon itself, or fP. It is evident that if the force P be removed, the material will drop away, but while the force P is existent there is always a downward force representing the weight of this overhanging body of earth, tending to increase the stability of the wall as though this overhanging earth were a part of the wall itself. The exact amount and point of application of this force is indeterminate, but I have used the amount fP and assumed it to be applied along the plane C—F or at the minimum distance out from B.

With these external forces acting upon the structure, conditions of equilibrium at any joint A—C require:

(1) That the sum of horizontal forces shall be zero.

(2) That the sum of vertical forces shall be zero.

(3) That the sum of moments about any point shall be zero.

To facilitate after-consideration, the stresses or reactions in the joint will be analyzed in accordance with as well known principle of mechanics that for a group of forces in the same plane there may be substituted at any point a single force and a couple, all forces being further resolved into their horizontal and vertical components.

The above conditions of equilibrium may now be expressed by the following formulas, moments being taken about B, the center of gravity of the joint A—C:

$$(1) \qquad R = P = \frac{w_1 h^2}{2}\left(\frac{1-\sin\phi}{1+\sin\phi}\right) \quad \ldots\ldots\ldots (7)$$

$$(2) \qquad p_1 b = W - X + V + F$$

from which follows:

$$p_1 = \frac{w_2 bh}{2(b-2)} - \frac{2 w_2 h}{b(b-2)} + \frac{w_1 h}{2b}(b-2) + \frac{f w_1 h^2}{2b}\left(\frac{1-\sin\phi}{1+\sin\phi}\right) \quad \ldots\ldots\ldots (8)$$

$$(3) \qquad M_r = \frac{p_2 b^2}{6} \text{ and } M_x = \frac{Ph}{3} + \frac{Wb}{6} - X\left(\frac{b}{2} - 0.67\right) - V\left(\frac{b+4}{6}\right) - \frac{Fb}{2}$$

from which follows by equating M_r and M_x:

$$p_2 = \frac{w_1 h^2}{b^2}\left(\frac{1-\sin\phi}{1+\sin\phi}\right) + \frac{w_2 bh}{2(b-2)} - \frac{12 w_2 h}{b^2}\left(\frac{0.5b-0.67}{b-2}\right) - \frac{w_1 h}{2b^2}(b-2)(b+4) - \frac{1.5 f w_1 h^2}{b}\left(\frac{1-\sin\phi}{1+\sin\phi}\right) \quad \ldots\ldots\ldots (9)$$

These formulas representing the relations existing between the forces and corresponding reactions at the joint A—C required for equilibrium, the conditions required by the nature of the construction are the same as given above in criticizing Mr. Boardman's method of design, and are expressed by the same equations (4), (5) and (6) there given.

Assuming now that A—C is the bottom joint of the wall proper, just above the foundation course, it will be of interest to observe the actual thickness of wall required by the first and generally the governing condition, namely, that no tension shall exist at point C. Substituting in Eq. (4) the values of p_1 and p_2 given in Eq. (8) and (9); substituting also for w_1 and w_2 their values as given above, there follows:

$$\frac{80 h^2}{b}\left(\frac{1-\sin\phi}{1+\sin\phi}\right) - \frac{1680}{b^2}\left(\frac{0.5b-0.67}{b-2}\right) - \frac{40}{b^2}(b-2)(b+4) - \frac{120 fh}{b}\left(\frac{1-\sin\phi}{1+\sin\phi}\right) + \frac{280}{b(b-2)} - \frac{40}{b}(b-2) - \frac{40 fh}{b}\left(\frac{1-\sin\phi}{1+\sin\phi}\right) = 0 \quad (4a)$$

Assuming now for the angle of repose ϕ such value as may be dictated by the designer's judgment and experience to approximate the conditions existing in the case at

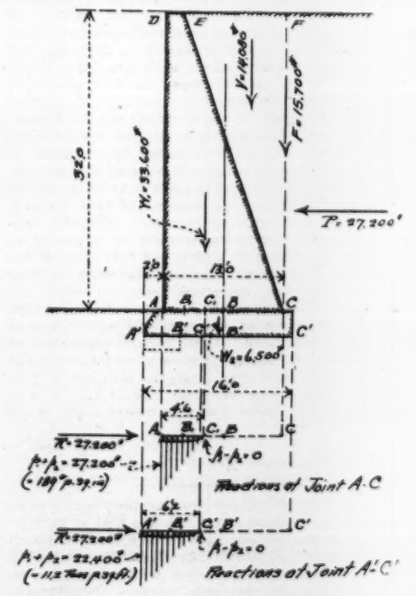


Fig. 6.

hand, and substituting same in Eq. (4a), the value of b and h in terms of each other may be easily determined.

In Fig. 4 are shown graphically, and in the table below by figures, the values of the base b for varying heights h as determined by this equation, the condition of backing being assumed to approximate, for Case 1, "loose earth" where ϕ is taken at 30°, and for Case 2, "damp clay"

where ϕ is taken at 45 °; also the corresponding data of the Pennsylvania R. R. design where the base is determined by the following formulas: $b = 1/3\,h + 3$, for values of h up to 18 ft., and $b = 2/3\,h - 3$, for values of h greater than 18 ft. In this table h and b are given in feet, and the toe pressure, $p_1 + p_2$, is given in pounds per square foot.

	Case 1, $\phi = 30°$			Case 2, $\phi = 45°$			P. R. R	
h	b	b/h	$p_1 + p_2$	b	b/h	$p_1 + p_2$	b	p/h
8...	3.0	.375	2.410	2.3	.288	2.500	5.7	.712
12...	4.7	.391	3.440	3.0	.250	3.780	7.0	.583
16...	6.4	.400	4.440	4.1	.256	4.840	8.3	.520
20...	8.1	.405	5.460	5.3	.265	5.890	10.3	.515
24...	9.8	.409	6.480	6.4	.267	6.960	13.0	.541
28...	11.5	.410	7.500	7.6	.272	8.030	15.7	.561
32...	13.1	.410	8.520	8.7	.272	9.100	18.3	.571
36...	14.8	.410	9.540	9.8	.273	10.170	21.0	.582
40...	16.5	.413	10.560	11.0	.275	11.240	23.7	.592
50...	20.7	.414	13.150	13.8	.276	13.940	30.8	.606

Examination of Fig. 4 will show that if the base b is determined as indicated by this method, and the back of wall made to conform to the straight line, as shown in Fig. 3, then all intermediate joints will be somewhat wider than necessary to fulfill the condition that no tension shall exist at the inner edge. For a high wall of any great length, it might be worth while to take this into account, calculating the values of b for several intermediate joints.

The back of the wall should always be stepped, about as shown in Fig. 3, and not left smooth, for this would tend to reduce the force F. If the wall were made rectangular, built up on the line C—F, the value of f to be used in determining the value of F should be, not that for "earth on earth" as here used, but the coefficient of friction of "earth on masonry" which is much less.

Taking now an example to show the effect of varying the thrust, Fig. 5 is cross-section of a wall 32 ft. high with all loads noted in place, the thrust being determined for the condition of "loose earth" where ϕ is taken at 30° as in Case I above. Below the cross-section of wall are shown the reactions resulting from these forces at joints A—C, between the wall and its footing course, and A'—C', between the footing course and the foundation bed below.

For the joint A—C, which is typical of any horizontal joint in the wall, there is a distributed force varying uniformly from 8,670 lbs. compression at the toe A to 150 lbs. tension at the heel C; and a horizontal force of 13,600 lbs. distributed over the joint. Considering these forces and assuming the wall to be built of concrete or masonry of the class ordinarily used in building retaining walls, the toe pressure is equivalent to a pressure of 60 lbs. per sq. in., whereas it could safely be from 300 to 500 lbs. per sq. in.; the heel pressure is approximately nothing, which conforms to the requirement that no tension be allowed at any part of a masonry joint; the horizontal force of 13,600 lbs. is resisted by the friction between the wall above and that below the joint, aided by the mortar. This resistance is much greater than the force R (that of friction alone, assuming that there were no mortar in the joint and that the coefficient of friction of dry masonry on dry masonry be 0.7, amounts to 38,850 lbs.), and need not be considered further.

For the joint A'—C', between the wall and the foundation bed below, the reactions are similar. The vertical distributed force varies from 7,100 lbs. (or 3.55 tons) per sq. ft. compression at the toe A', to 680 lbs. compression at the heel C'; the former being about right for the allowable pressure on a first-class earth foundation, and the latter being about right to meet the condition that there be no tension in the joint. The horizontal force R of 13,600 lbs. is resisted by the friction between the wall and the foundation bed below; taking the coefficient of friction between the wall and earth at 0.4 the frictional resistance that could be counted on to resist the force R would be 24,810 lbs. or 82% more than necessary.

Thus it appears that for this design the governing conditions are that there be no tension at the heel for any joint and that the pressure at the toe of the foundation course be kept within the limits allowed on the ground supporting same. It will be noted also, that to fulfil these conditions the material used in construction of the wall is strained in compression and shear to a very small part of its allowable stress, and, moreover, the weight of wall acts with the horizontal thrust to increase the moment about B' and consequently the toe pressure on foundation bed.

To determine now the effect of increasing the earth pressure, I have shown in Fig. 6 the outline of this same wall with the same forces acting thereon excepting P and F which are doubled. Below the cross section of wall are shown as in Fig. 5 the resulting reactions at joints A—C and A'—C' necessary for equilibrium.

As the force P of Fig. 5 increases, the toe pressure at each joint increases while at the heel the pressure is reduced, and as there can be no tension across the joint, the heel lifts up and a readjustment takes place, shifting the compressed area of base over towards the toe until finally with the forces indicated in Fig. 6 the joint A—C is compressed for a distance of 4.6 ft. and A'—C' 6.2 ft. from the toes A and A', respectively. For the joint A—C the toe pressure is 27,200 lbs. per sq. ft. or 189 lbs. per sq. in., and for joint A'—C' the toe pressure is 22,400 lbs. or 11.2 tons per sq. ft. These reactions are determined as before, p_2 by taking moments about the new centers of gravity of base B_1 and B_1', and p_1 by dividing the sum of all vertical loads by the area of the new bases A—C_1 and A'—C_1', respectively, for the two joints.

The reaction R of 27,200 lbs. at A'—C' is again resisted by the frictional resistance of the wall against sliding on the foundation below. Using the same coefficient of friction, 0.4, as before this resistance will amount to 27,950 lbs. or about 3% more than necessary, though as a matter of fact, for a foundation bed that would withstand a pressure of 11.2 tons per sq. ft. as required by the toe pressure, the coefficient of friction would be much greater than the 0.4 used here.

Examining these reactions then it appears that for a foundation bed of earth, the governing condition under the loads shown in Fig. 6 will be the pressure on the earth at the toe C' of the wall; if 11.2 tons per sq. ft. be allowable, then the wall is still safe and might be said to have a factor of safety of 2 over the condition of loading shown in Fig. 5.

If the horizontal thrust be now increased so as to shift the bearing area of the joint A—C over to within a foot of the toe A, the toe pressure at A will approximate 1,000 lbs. per sq. in. and would probably crush the masonry itself here. Thus, even if the wall were built on solid rock so as to eliminate the conditions at the joint A'—C', it would not be proper to determine its efficiency by assuming it to revolve about its toe or even a point 6 ins. in from the toe.

The above analysis would indicate that a wall built as shown in Fig. 5, which probably represents the average practice, would be quite safe provided the foundation be capable of resisting safely the developed toe pressure of 3½ tons per sq. ft. And if it were desired to increase the efficiency of the wall, efforts should be directed towards increasing, by driving of piles or otherwise, this allowable toe pressure.

The same general method as outlined above can be used in designing reinforced concrete walls, and in fact any structure of this nature.

The method proposed by Baker in his Masonry Construction (Article 545), where, after discussing at length the various theories of retaining walls, he sums up by suggesting that because something must be assumed it is better to assume the thickness of wall at the outset that to make a rational assumption as to the forces and then evolve a structure to meet the conditions of loading, appears to me very unscientific, and certainly one that will not be satisfactory when applied to retaining walls other than of solid masonry.

Yours very truly,

Chas. Worthington.

134 West 70th St., New York, Aug. 19, 1905.

Sir: In your issue of Aug. 17 the question of strength of retaining walls is taken up by Mr. H. P. Boardman. Now, the very paper referred to therein, viz.: "The Actual Lateral Pressure of Earthwork," by Sir Benjamin Baker, printed in book form from minutes of the Institution of C. E., of Great Britain, shows the very great divergence of opinion on the subject among engineers. The date of the discussion is, however, 24 years ago, and while it is perfectly true, as Mr. Boardman states, that the reports on the behavior of retaining walls of various types on nine miles in one case, and 34 miles in another, is interesting, it must be admitted that it is not really very instructive, from the fact that it mainly treats of masonry walls, and it is generally admitted at the present time that concrete is the proper material for present needs.

Sir Benjamin Baker, towards the latter part of his paper mentions the use of concrete, and commends it, and on page 109 says, "he has used it in many varieties of structures as long back as fifteen years ago," and farther remarks that "nothing but blasting would separate counterforts from a good concrete wall and the non-use of counterforts requires reconsideration in these days of cheap, strong and easily molded concrete. These statements are truly interesting since the use of counterforts and the use of concrete are both commended. Trautwine (see page 692) says of counterforts: "We conceive them to be little better than a waste of masonry, when a wall of this kind fails it almost invariably separates from its counterforts, to which it is connected merely by the adhesion of the mortar, and to a slight extent by the bonding of the masonry. Now if Trautwine had stated that counterforts are useful only when the connection to the main part of the wall is of such strength as to develop the inertia and friction of the counterfort, then it would not be an out-of-date assertion, but would fit into modern practice.

Baker mentions Rankine's assertion to the effect that horizontal ledges on the inside of a wall are "as good as masonry" only to deny that it is so, his denial being based upon the discovery in one instance of such a wall, where the earth filling had arched so as not to bear against the horizontal ledge. Neither Baker nor Trautwine take up the question of the friction of the filling upon the sides of the counterfort although Baker says something in an off-hand way about "the binding of the ballast between the counterforts" (see Baker, p. 26), and at the same time he admits that in one instance the bulging of the wall was 2½ ins. in the 10-ft. panels, and but 1½ ins. at the counterforts. It might be possible to make a mathematical examination of this case to discover the excess inertia in the counterforts due to excess weight and friction, but Baker's own statement shows they were doing a great deal.

Again on p. 110 Baker says "Portland cement concrete being thus possessed of such great tenacity there is no risk of counterforts separating from the body of the wall," "but it by no means follows that there would be any advantage in using them in other than exceptional cases," and on p. 111 he continues, "It follows, therefore, that under the stated conditions the adoption of a counterforted wall would lead to no economy in material, while it would involve additional labor in construction."

The experiments of Lieutenant Hope mentioned by Baker, when tests were made with dried peas for backing and wooden blocks for masonry, and the investigations of Mr. Jamieson on pressures in wheat bins mentioned by Mr. Boardman, do not help out in the solution of the problem in any degree. On p. 117 Baker says "the use of the numerous published tables giving the calculated required thicknesses of retaining walls to three places of decimals, stand really on exactly the same scientific basis, and have the same practical value, as the weather forecasts for the year in Old Moore's Almanac," and again he says, "If an engineer has not had some failures with retaining walls, it is merely evidence that his practice has not been sufficiently extensive, for the attempt to guard against every contingency would lead to ruinous and unjustifiable extravagance."

This latter quotation will be a balm to those engineers who have made mistakes, for with such an axiom as a guide, it will be a difficult matter for any corporation to determine whether the failure be due to commendable economy, or to bad judgment on the part of the engineer. The rule that would attach to this, however, would probably be, that a very large percentage of the work should stand, and but a small percentage fail, if the engineer's reputation is to remain at par. The ordinary engineer would prefer, however, that all of his work should stand up to its requirements. Now, a summary of the situation is this:

(1) That the time of a general use of concrete has arrived, and the reinforced concrete is a tremendous advance over masonry.

(2) That the advantages of counterforts under the new conditions must be very great.

(3) That the squeezing action of earth filling must have a great effect in holding onto counterforts to prevent forward motion.

(4) That the forces tending to force out the wall may be operative back of the wall to a considerable distance, or may be operative only in a thin film of earth or a thin column of fluid pressure.

(5) That the lowest stratum of excavation, viz., the undersurface of the wall, i. e., its base, may attract moisture, and thus engender a very low coefficient of friction.

(6) That the origin of the moisture may be from the surface, or may be from sub-strata regions.

(7) That surface moisture may follow downwards in a thin column, or may be present in an extended area back from the wall, but is reasonably certain to be present in greatest degree next to the wall and to diminish in quantity farther back from the wall.

(8) That the base of counterforts may be kept higher than the base of the wall and thus in great probability have a better coefficient of friction, because of better drainage.

(9) That counterforts extending back into the bank would in all probability secure a dryer hold to the bank by side friction.

(10) That horizontal ledges are an advantage and that Rankine's claim that "earth resting on horizontal ledges is as good as masonry" is a truism, meaning, of course, pound for pound.

(11) That the back and base of retaining walls should be drained where at all possible.

(12) That frost is irresistible, and its action against a wall is to be measured by the degree of compactness of the filling, and with frozen earth to push against on one side, and the wall on the other, that the wall must move, and each successive occasion of freezing will be a new trial of strength between the compactness of the filling and the stability of the wall, and unless the filling yields the wall must move.

(13) That the lower the horizontal ledge is the greater value it will have, because of the greater load of earth on it.

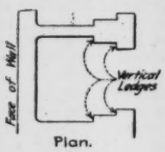
(14) The lower portions of the counterfort will have greater squeezing value from the filling, but not in direct proportion to the height, nor as the square of the height, but at some indeterminate ratio.

(15) That in the event of frost action in the upper layers, the value of the squeezing pressure on the counterforts would be increased, and the backing would have to be harder and able to withstand a greater pressure in order to force the wall forward.

Now, these conclusions will give a fairly definite idea of what a retaining wall should be like, and I would assemble them as follows, viz.:

(a) A light face wall with counterforts.
(b) Ample surface subject to friction for the counterforts.
(c) No need of great thickness of counterforts.
(d) Strength at juncture of face wall and counterforts to deliver accruing loads (steel reinforcement).
(e) Horizontal length of counterforts into the bank to be least for dry situations, soft filling and in tropical countries, and greatest for wet soils, hard filling or cold climates.
(f) Horizontal ledges to be run far under the bank, the distance to be proportionate to the importance of the work, and the possible inconvenience or disaster following failure. The greatest efficiency is obtained when these ledges are near to base of wall.

Then Rankin's idea of earth on a horizontal ledge being as good as masonry, should be applicable to vertical ledges, which would make a counterfort on plan appear like Fig. 1.



Plan.
Fig. 1.

This form would be particularly valuable in cases of efficient backing accompanied by fluid or other severe pressure in the vertical planes next to the inside face of the wall.

It must be admitted that no definite and final conclusion can be arrived at as to the real actual pressures existing behind a revetment wall. The conditions are very uncertain, since so many changeable factors control the situation.

The point of attack, as we might call it, may be at the base of the wall, due to heavy clay and quicksand with water, or it may be at the middle height such as the pressure of an ordinary prism of earth, or it may be at the top of the wall from surface water subjected to frost, or it may be from fluid pressure, which would concentrate at two-thirds of the depth to which the fluid extends.

The filling should be porous and drained by weep holes and also by tile drains leading to an outlet that is protected from freezing, for weep holes may freeze up and become useless.

The upper layer of filling should be clay puddle and gravel, paving stones or sod, so as to shed the water, but this layer should not be thick and immediately beneath it should be porous material connecting to efficient drainage.

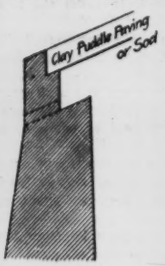


Fig. 2.

Where the wall and filling meet at the top there should be a drain so that this joint shall not be a means of carrying water down the inside face of the wall, Fig. 2.

A wall of 0.5 the height with vertical back and front faces, may be reduced by 10% to form a low horizontal ledge and by 1% to form counterforts. With 10 ft. height the ledge would be 10% of 50 ft. = 5 sq. ft.

With original wall a b c d 5 ft × 10 ft. we would reduce the width to 4 ft. 6 ins. and place the ledge at f g h k 1 ft. × 5 ft., Fig. 3.

One per cent. of fifty would be 0.5 ft., which would be the area of the counterfort for each foot in length of wall, and with 10 ft. spacing of the counterforts would give 0.5 × 10 or 5 sq. ft.

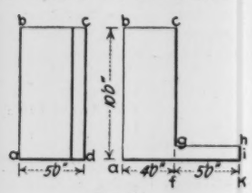
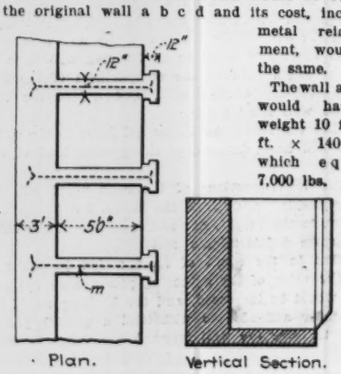


Fig. 3.

This would give a plan as shown in Fig. 4. Taking another 9% from the original 50 ft. area to allow for payment of the extra labor and excavation involved in building such a wall as compared with a solid wall, would leave 3 ft. as the thickness of the front wall.

The total area of the wall shown would be 9% less than the original wall a b c d and its cost, including metal reinforcement, would be the same.

The wall a b c d would have a weight 10 ft. × 5 ft. × 140 lbs., which equals 7,000 lbs.



Plan. Vertical Section.
Fig. 4.

The new wall would have a weight
7,000 less 10% = 6,300 lbs.
and earth 5 ft. × 9 ft. × 100 = 4,500 lbs.
10,800 lbs.

and no fine mathematics are required to prove that the counterforted wall will have nearly double the stability against sliding and against overturning that the wall a b c d would have.

The same rule of proportion would hold good for walls of 0.4 height, 0.3 height, or any proportion.

A still greater stability could be obtained by reducing the distance the horizontal ledge runs into the bank, and increasing the distance the counterforts extend into the bank. The expense of excavating so far back as shown may be in some cases prohibitive, but holes to receive the wedge shaped counterforts would be more easily excavated.

Yours truly,

Jno. S. Fielding.

15 Toronto St., Toronto, Ont., Sept. 26, 1905.

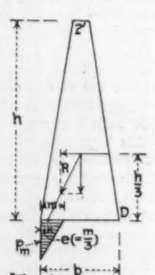
(A proof of the above letters was furnished to Mr. Boardman and we append his reply below.—Ed.)

Sir: Replying to Mr. Worthington's discussion of my article in Engineering News of Aug. 17, I think he is laboring under several misconceptions as to purposes and accuracy of some of the steps in my argument.

In the first place he refers to my "theoretical treatment of the problem." I had no intention and think I made no claim of treating the problem from a theoretical standpoint. There is an abundance of theoretical discussion of the subject in various books and technical papers, and I did not think I could add anything of value in that line until more actual experimental data (on a large scale) were available.

The calculations I made were merely attempting to show: (1) That for a given thickness at top and bottom and a given height of wall it makes considerable difference whether the batter is on the front or rear, or, what is the same thing, that for equal stability we must have more thickness at the base when the face is vertical than when it is battered. (2) The approximate relation between the thickness of a typical solid wall and the weight per cubic foot of a fluid whose pressure would just render the wall in unstable equilibrium, or on the point of overturning. The object of getting this relation was merely to suggest a method of designing a reinforced concrete wall of ultimate stability equal to that of a given solid wall. As to Mr. Worthington's criticism of some of my assumptions: (1) That the wall rests on an unyielding base, and (2) that moments be taken about the toe of the wall. Of course, to be exact, nothing is absolutely unyielding and the use of that word, unqualified, may be open to criticism. I endeavored, however, to make it plain by statement and by Figs. 2 and 3 that my calculations only applied to the retaining wall proper above the footing, the thickness of the base of this main wall being the dimension frequently assumed as bearing some fixed ratio to the height. I did not discuss the dimensions or projection of this footing under the solid wall, having no intention of advancing a complete treatise on the subject of retaining walls, but assumed this footing to be large and firm enough so that the critical section would be at the base of the main wall and on top of the footing, which footing may be considered as a rock foundation. In the article under discussion I expressly stated that I made no claim to great accuracy regarding these assumptions.

In taking moments about the toe of the wall I had in mind a monolithic concrete wall having no adhesion to the footing, i. e., no capacity for transmitting tension across the joint at base of wall. Referring to the accompanying Fig. A, when the resultant pressure R intersects the base outside of the middle third there will be a slight opening up of the joint at D due to a variable compression near the toe, as indicated by the shaded triangle of compressive stresses. But the wall will still be in stable equilibrium until this resultant moves forward near enough to the toe of the wall to cause failure by crushing. The ultimate crushing strength of concrete usually ranges in tests between 1,500 lbs. and 3,000 lbs. per sq. in. Granting that in the case under consideration failure might result when the compression of the extreme fiber was much less than the ultimate unit stress of test cubes, let us assume p_m = 144,000 lbs. per sq. ft. (= 1,000 lbs. per sq. in.), see Fig. A.



Eng. News. Fig. A.

Let h = 20 ft. Let wt. per cu. ft. of concrete = 150 lbs.

Let b = 8 ft.

Then since ∴ Vertical forces = 0, the area of the compression triangle = the weight of the wall or

$$\frac{144{,}000 \text{ m}}{2} = \frac{150 \ (2 + 8)}{2} \times 20$$

$$\therefore \text{ m} = \frac{15{,}000}{72{,}000} = .208 \text{ ft. or } e = .069 \text{ ft.}$$

This wall being symmetrical the moment arm of the weight of the wall would be $\frac{5}{2} - e = 3.931$. Then on the basis of the above assumptions this particular wall would have a moment of stability of $\frac{3.931}{4} = 98.27\%$ as great as if the moment were taken at the actual toe of the wall. Two per cent. or even five per cent. is not a bad error for any assumption concerning retaining wall stability, especially when it is expressly stated that great accuracy is not claimed."

In Mr. Worthington's criticism of my formula and table showing the relation between the thickness of the wall and the "equivalent fluid pressure" it is evident that he did not very carefully read my statement made just previous to the enumeration of assumptions at the bottom of the last column of page 167. Here I made it plain that the "w," or equivalent fluid pressure I was considering is the *ultimate* "w," i. e., one which would place the wall on the point of turning over. Mr. Worthington takes my numerical example of "w," 50 lbs., and solves for a thickness of wall such that his line of resultant pressure intersects the base of the wall at the forward limit of the middle third, giving what is commonly called a factor of safety of two. No wonder his results are high. My values of b/h in this table are within the limits of common practice in building retaining walls, and do not differ materially from those obtained by Mr. Worthington under case I, (ϕ = 30°) in his later discussion.

Supposing that for a given set of conditions and materials we know all the elements involved in the problem which depend on the earth pressure and the action of the forces within the body of the earth, then a treatment of the problem similar to that Mr. Worthington gives in Figs. 3-5 and 6 and the accompanying discussion is very proper and desirable. But do we know enough about the amount and direction of the actual pressure exerted to warrant all this calculation even when we think we know all about the back-filling used? For instance, since writing the article under discussion I learned of a partial failure of a retaining wall which started to tip forward. The failure, as usual, was caused by the yielding of the soil under the toe of the footing, and the main cause seems obvious from the fact that the back-filling behind the wall had been carried nearly to the top while the trench in front of the wall was still open, giving an opportunity for rain or ground water to soften up the soil just where it received the maximum pressure. Now suppose Mr. Worthington were informed of all the known facts concerning the back-filling, section of the wall, etc. (which I am unable to give), could he calculate the pressure on the soil under the toe of this wall at the time of failure and be willing to swear in court that his results were within 25% of correct? I doubt if he would be willing to swear that they were within 50% of correct. If that is true, then I think we need more experimental information on this subject of earth pressures.

The way to prevent such failures as the above is not by increasing the thickness of the base of the wall, but to insist on proper care in construction, and especially in placing the filling both behind and in front of the wall. But while the field and not the office is the place to guard against such failure, the designer can do better work the more he knows about the subject. I think so much has been cited at variance with the theories of earth pressure that the only excuse for using them is the lack of anything better, and the habit of making this excuse keeps us in the old rut and prevents the adequate search for something better.

I do not believe experiments on a small scale are of much benefit, because the pressures involved are not sufficient to compress the filling and bind the particles together as in deep back-filling. The deeper the filling the greater the density at the bottom, with the possible exception of granular material, in which the particles are nearly uniform in size. For this reason and because of the indications of some experiments, I think the lateral pressure in solids does not increase nearly in proportion to the depth. In accordance with this conclusion, I favored, in my article of Aug. 17, the designing of retaining walls having an *ultimate* moment of stability *equal* to that of a *typical solid wall* whose thickness bears a constant ratio to its depth, because this corresponds to an equivalent fluid pressure gradually decreasing as the depth increases. I used b/h = .4 for the typical solid wall merely as an example, but would not recommend that ratio for all cases any more than I would recommend the same strength of bridge for railway as for highway traffic.

I seek to discourage the use of the theoretical formulae because I believe them to be based on *assumptions radically wrong* and wish to *stimulate a search for something better.*

I agree with Mr. Fielding that this is the day of rein-

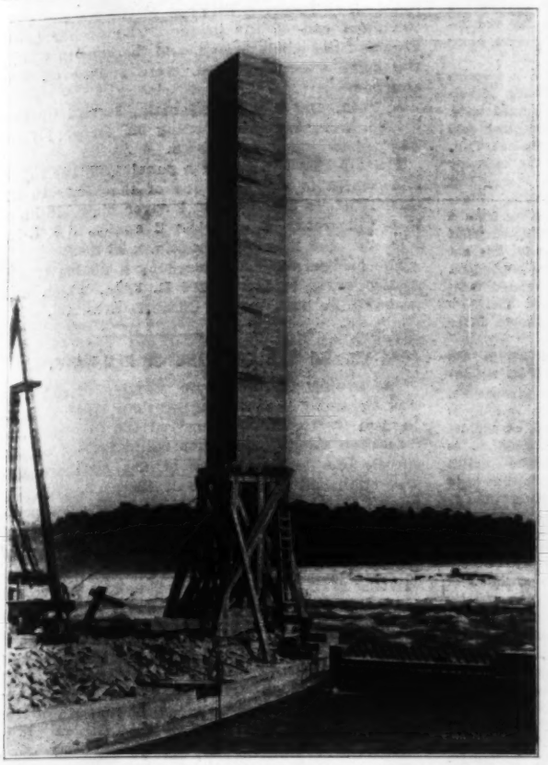


FIG. 1. TOWER OF CONCRETE BLOCKS DESIGNED TO BE OVERTURNED TO FORM SUBMERGED WEIR IN RIVER.

forced concrete, and that it is especially suited to the building of retaining walls. I also agree with him that counterforts securely anchored to the face wall add greatly to the stability, and that when accompanied by a floor or back step, as in his Fig. 4, also properly reinforced, they result in making all the filling in the spaces between the counterforts an integral part of the wall and moving the center of pressure on the soil below, much further back from the toe than would be possible with the solid type of wall containing an equal quantity of concrete or masonry. But from the standpoint of economy of construction and maximum efficiency per cubic yard of concrete, I think the more common type as shown in Fig. 5 of my previous article has the advantage. Here the counterforts are triangular and serve to inclose the steel reinforcement, tying the face wall to the back steps of the footing. I think it also worth while, where possible, to make use of a forestep or front projection of the footing also reinforced if its horizontal projection exceeds about 60% of its depth.

Large coal piles are often retained by building a face of lumber and anchoring it by tie rods passing diagonally down through the coal. If the face wall and the rods are strong enough and the latter carried back far enough from the foot of the pile, the failure of the structure is as impossible as it is for a man to lift himself by his own boot straps. The above mentioned type of reinforced concrete retaining wall makes use of the same principle, and can be made much more stable against overturning than a solid wall of the same volume per linear foot.

Of course any wall making an economical use of steel reinforcement will cost more per cubic yard of concrete both in form work and in placing bars and concrete than will a solid type of wall, and in this respect I think the type shown by Mr. Fielding's Fig. 4 is open to criticism.

The proper reinforcement of counterforted walls is a problem and especially the question of whether it is necessary to connect the reinforcing bars of the counterforts directly to those of the front wall. In Mr. Fielding's type the face wall would not receive as great pressure from the earth as in most others, because the counterforts would take much of this pressure direct.

H. P. Boardman.
6600 Ellis Ave., Chicago, Ill.,
Oct. 28, 1905.

THE RAILWAYS OF SWITZERland, which are all owned and operated by the Federal Government, with the exception of the St. Gotthard line, are likely to be altered to electric traction. According to the "London Times" of Oct. 18, a national commission has in preparation plans for the acquirement by the government of the water powers most available to furnish the current for railway traction. In a recent discussion in the Federal Council, however, it was stated that no system for the electric operation had yet been decided upon and the change to electricity will probably not be made for several years to come.

AN AUTOMATIC SWITCH invented by Mr. Hooper and Mr. T. King Wilson, of Chillicothe, O., is now being introduced, and the first one made has been in use on the Baltimore & Ohio Southwestern Ry. for some months. The switch is normally set for the main track, and when it has been set for the siding it is automatically released and returned to its normal position as soon as the last wheel of the train (going in or out of the siding) has cleared the switch. The design has been simplified and improved since the first switch was built, and it may be controlled by either electrical or mechanical apparatus.

CONSTRUCTING A SUBMERGED WEIR BY OVERTURNING A TOWER OF CONCRETE BLOCKS.

Plans for the construction of a submerged weir at the intake of the Niagara Falls Park & River Ry. powerhouse, by overturning a tower of concrete blocks were described in our issue of Oct. 12. The accompanying views show the tower completed, in the process of overturning, and in its final position in the river after being overturned. As indicated by the views the novel plan of construction was a complete success. The water in the fore-bay was raised 0.85 ft. or 10.2 ins., which is deemed sufficient for present purposes.

Some delay was occasioned in overturning the tower because of carelessness in following the engineer's plans in constructing the wooden base for the tower, but the errors were remedied and the tower was overturned on Nov. 9. The tipping timbers were raised 6 ins. by jacks; this threw the top of the tower 36-ins. out of plumb, which was just enough to cause overturning. The timber base fell with the tower proper and served perfectly its intended purpose of dropping the river end of the chain of blocks far enough away from shore to leave a space between it and the shore for an ice runway. This space is 15 ft. The tower struck the water in an almost horizontal position. The cast-iron dowels broke as expected, and, besides, two of the concrete blocks, striking submerged boulders, broke in the middle. This was caused by the fact that the concrete blocks could not be completed each in one day, and had to set over night and be built up further next day, so that there was almost as distinct a line of cleavage in the middle of the blocks as there was at their top and bottom where they were separated from each other by tarred paper. In this case the result was not injurious, but Mr. Isham Randolph, the engineer who devised the method of construction, says that in case he has occasion to use the same method again, he will obviate the difficulty by reinforcing the concrete blocks by steel bars running entirely through them and strong enough to stand the shock. The obelisk, as was desired, conforms to the bottom of the stream and projects somewhat above the surface of the water, presenting a jagged appearance.

A COMPARISON OF THE RECENT BRITISH AND AMERICAN SPECIFICATIONS FOR CEMENT.*

By R. W. Lesley, Assoc. M. Am. Soc. C. E.†

Comparing the specification for cements of the Main Engineering Standards Committee of Great Britain (Engineering News, March 2, 1905) with that of the American Society for Testing Materials (Engineering News, June 30, 1904), it is to be noted, first, that it is shorter, more compact, and embodies in four large pages of printed matter, covering a series of articles numbered from 1 to 12, all that which in our specification 32 pages are taken to describe. The specifications embody in the one case 12 articles, in the other 25 articles, which latter in turn cover 76 more. This condition of our specifications is due to the embodiment in and under the Standard Specifications of the American Society for Testing Materials, of the Progress Report of the American Society of Civil Engineers and the Report of the New York Section of the Society for Chemical Industry. When, however, the two specifications are again compared, it will be noted that the British specification covers in its 12 articles all that there is to be said upon both manipulation of tests and specifications for tests, but that it omits entirely all reference to chemical analysis, which is evidently not considered to belong to a standard specification for Portland cement.

In comparing the two specifications, therefore, it is necessary to consider both the reports on methods of manipulation and standard specifications above referred

*Abstract of a paper read before the American Society for Testing Materials at its annual meeting in June, 1905.

†604 Pennsylvania Building, Philadelphia, Pa.

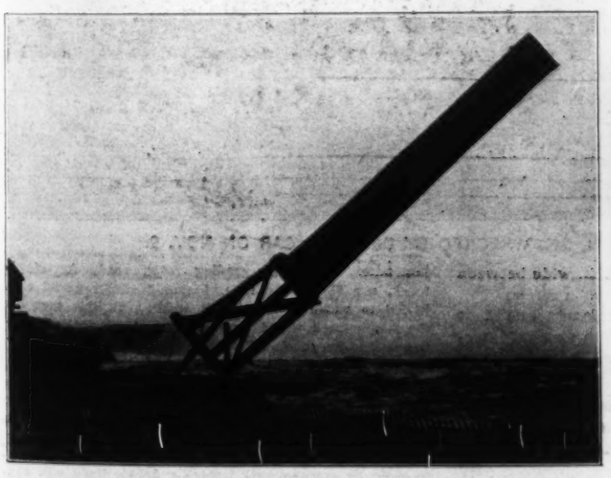


FIG. 2. VIEW OF CONCRETE BLOCK TOWER IN PROCESS OF FALLING.

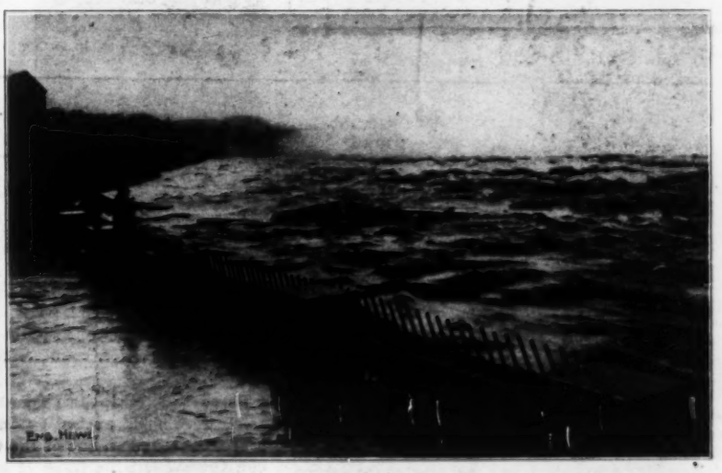


FIG. 3. VIEW SHOWING POSITION OF FALLEN TOWER IN RIVER.

to, omitting alone the methods of analysis. Without going over the entire methods of manipulation required by the Progress Report of the American Society of Civil Engineers, nor dealing with those parts of the British specification which have to do with methods of manipulation alone, but getting down simply to the differences in specifications, which, after all, are those which are likely to interest engineers, consumers and manufacturers, it may be stated in a general way that on the first item of the definition of Portland cement the British specification suggests both water and sulphate of lime as materials which may be added to retard the setting, and covers both in its specification, limiting the amount in either case to 2%. In the American specification it will be noted that any addition, subsequent to calcination, is limited to 3%.

On Specific Gravity, both specifications practically agree at 3.10, but the English specification raises the amount to 3.15, where cement is sent direct from the mill to the laboratory in tightly sealed packages.

On fineness, there is a material difference in the screens used, and it may be stated that the American specification, which has 8% on a No. 100 (10,000 mesh) sieve, and 25% on a No. 200 (40,000 mesh) sieve would require a finer grinding than the British, which has 3% on a 5,776 mesh sieve, or 22½% on a sieve of 32,400 meshes.

In the matter of setting, the specifications are again at variance. Our specifications require that the cement shall develop initial set in not less than 30 minutes, but must develop hard set in not less than one hour nor more than ten hours. The English specification recommends three distinct grades of setting time, designated as quick, medium and slow. The first is not less than 10 minutes nor more than 30 minutes; the second is not less than one-half hour, nor more than two hours, and the third in not less than two hours, nor more than five hours; and yet while these grades of time of setting are recognized, and each of them will have a material bearing upon the tensile strain of cement, the British specification in the matter of tensile strength has but one series of limits, namely:

	7 days.	28 days.
Neat	400 lbs.	500 lbs.
3 sand, 1 cement	120 "	225 "

The American specification, on the other hand, while not recognizing different classes of cement, so far as the time of setting is concerned, does recognize different strengths in tension, and has what the British specification has not, a 24-hour test, which may possibly in some quarters be considered superfluous for Portland cement. The American requirements are:

	7 days.	28 days.
Neat	450 to 550 lbs.	550 to 650 lbs.
3 sand, 1 cement	150 to 200 "	200 to 300 "

They are all higher than those of the British specification, which is no doubt due to the fact that there is more rotary cement manufactured in our country than possibly anywhere in the world.

Interesting, however, is the difference in the matter of gain in strength at longer periods, a new requirement which has only just come into cement testing since the introduction of the rapid transit specification in New York. In our country, in view of the fact that the matter has not been thoroughly settled, we recognize broadly that no cement shall show retrogression. In the English specification, however, this increase of strength between the 7-day and 28-day periods is graded according to the initial strength shown by the cement at the seven day period, which seems to be a very fair method of determining increased strength between the periods stated. In their specification, a cement showing 400 to 450 lbs. at 7 days is to gain 25% in 28 days; 450 lbs. to 500 lbs., 20%; 500 to 550 lbs., 15%; and all over 550 lbs. at 7 days an increase of 10% at 28 days. This, as can readily be seen, is a very fair view of the subject, as a cement that pulls 600 to 700 lbs. at 7 days will have to increase very many pounds in tension to acquire the strength to show 25% increase between the 7-day and 28-day periods, while a 10% increase would be a much more reasonable figure.

The great and salient difference between the two specifications is that governing the test for constancy of volume, or what are known technically as accelerated tests. In our specification we have adopted the hot and cold water tests prescribed under the German Normal Test, and which have been in use so successfully for so many years, and have supplemented them by a steam test after the cement is set for 24 hours, consisting in exposing the pat in an open vessel to steam rising from a body of water beneath. The British have adopted what is known as the Le Chatelier test, and which so far has not been generally adopted outside of France. This is the part of the specification which up to date has attracted most criticism, by reason of possible inexperienced operators not producing similar results with similar cements under similar circumstances.

The chemical requirements of cement differ in the two specifications, as follows: In the American specification 1.75% of anhydride sulphuric acid is permissible, while in the British specification the limit is run up to 2.5%. In England 3% of magnesia is allowed, as against 4% in this country. Insoluble residue in England is limited to 1.5%. Another interesting thing in the English specification is that there is no excess of lime: that is to say, the proportion of lime shall not be greater than is necessary to saturate the silica and alumina presented, or that represented by the formula $\frac{CaO}{SiO_2\ Al_2\ O_3} = 2.75$.

Of course this would be covered by the analysis of cement described in the methods of manipulation of tests of the American Society of Civil Engineers, and the Methods of Analysis of the American Chemical Society, which are part of the American specification.

It is interesting to note that while the Standard American Specification has so far stood fire very well, and even its makers could only suggest unimportant typographical corrections at our present meeting, the English Standard Specification has not been so fortunate. From several quarters there has been some little criticism on the accelerated tests accompanied by statements of different results on the same sample. There have also been some other unimportant criticisms on chemical composition. Whether the difference in mental attitude to the new specifications in the two great English speaking countries is due to the respective national characteristics of their people is still to be determined. To the speaker, both specifications betoken good, careful thought and work conscientiously done.

A BRIDGE KNOCKED DOWN BY A DERAILMENT.

A pin-connected, single-track, through truss bridge over the Little Conemaugh River at Johnstown, Pa., was knocked down by a derailed car, on Nov. 9, causing a wreck which is illustrated in the accompanying photographs. The bridge had a span of 162 ft., and was 16 ft. wide between truss centers. Both ends were on a skew.

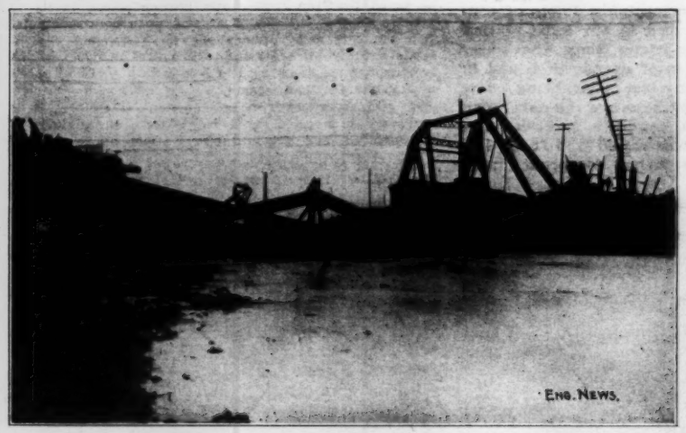
The top chords, end posts, stringers and floor beams are of steel and the bottom chords, intermediate posts, ties, counter-rods, and all bracing of iron.

Three cars, each carrying about 110,000 lbs. of steel, were being pushed by an engine. Owing to a broken flange on one of the wheels of the front car, the car left the track at a switch, when only a short distance from the bridge, and before it could be stopped ran into one of the end posts at the fixed end of the bridge. The anchor bolts held and the whole bridge, and the caps in which the bolts were embedded, were pushed off the abutment.

A 16-in. and a 6-in. gas main, carried by the bridge, were severed, shutting off the supply of gas to the city of Johnstown.

The top chord in the fifth panel from the roller end, which is shown in one of the views to be so twisted, is made up of 1 cover plate, 15-in. × ⅜-in.; 2 webs, 16 × ⅜-in.; 2 angles, 3 × 3-in. × 18 lbs., and 2 angles, 5 × 3-in. × 36 lbs.

The bridge will be replaced by a double track, riveted truss bridge of 207-ft. span, which will probably be built by the Cambria Steel Co.



BRIDGE OVER THE LITTLE CONEMAUGH RIVER AT JOHNSTOWN, PA., WRECKED BY DERAILED CAR ON NOV. 9.

THE DOUBLE TRACKING OF RAILWAYS.

The subject of the double tracking of railways was discussed at some length in our issue of Sept. 14, and we have since received the following information from some other railways; an article on the double-track work of the Southern Ry. was published in our issue of March 2, 1905. In regard to the matter which follows, the two principal features are the traffic conditions in regard to double-tracking, and the estimates of cost of single and double track. The double tracking of existing main lines now forms such an important part of railway improvement work, and involves so many special problems as to cost and methods of work, that we believe the information presented in this and the preceding articles will be of special and practical value to engineers engaged in the planning or execution of work of this kind.

SOUTHERN RAILWAY.—When we come to double track a division we are usually confronted with the following conditions, approximately: Trains each way per day: 6 through passenger trains, 5 mixed passenger trains, 5 through fast freights, 4 local fast freights, 5 mixed and work trains; or say 50 trains per day on the division. Sometimes there are a few less, sometimes more. In our system, when we reach the above condition another condition arises; that is, our gross earnings per mile approximate $20,000. So that in general terms I would say where we are running 50 trains a day or earning $20,000 gross per mile per annum it is advantageous to double track the line. As to the cost of double tracking, that is a hard question and depends upon the character of country traversed. In so far as the track superstructure is concerned (rails, spikes, fastenings, ties, ballast and laying track), double tracking doubles the cost, and using 80-lb. steel, other things in proportion, these items cost on our system about $9,450 per mile. Where the grading costs, ready for single track, say $8,000 per mile, I should say it would cost $3,000 to widen it for double track. In this instance the single track would have cost $17,450 per mile, while the second track would cost $12,450. As the country becomes rougher, the price of double tracking approximates more nearly to double that of a single track. And where we come in contact with much masonry, bridging and tunnels, the second track may (and in many instances will) exceed the cost of the original single line unless we gauntlet important bridges and tunnels, as is frequently done. In ordinary average work I think a double track will add from 50 to 75% to the cost of the original single track.

DENSITY OF TRAFFIC ON DOUBLE-TRACK; SOUTHERN RAILWAY

	Miles.	North Bound—Pass.	North Bound—Freight.	North Bound—Total.	South Bound—Pass.	South Bound—Freight.	South Bound—Total.	Total No. of Trains.
Seymour to Howell	3.3	6	12	18	6	13	19	37
Clayton to Austell	11.2	8	19	27	8	20	28	57
Jefferson to New Line	10.5	5	13	18	5	13	18	36
Linwood to M. P. 128	11.0	5	13	18	5	13	18	36
Spencer to Linwood	8.5	8	10	18	7	11	18	36
Pomona to High Point	12.1	8	11	19	8	9	17	36
Greensboro to Pomona	3.7	11	14	25	11	12	23	48
Danville to Pelham	8.7	8	10	18	8	10	18	36
Manassas to Orange	52.8	12	9	21	17	9	26	47
Alexandria to Manassas	25.7	13	9	22	18	9	27	49

and in extreme cases it may add more than 100%. The unit prices for double tracking, generally speaking, are about 25% higher for double-track work than for single track owing to interferences from passing trains, particularly where there is much masonry to renew or blasting to be done in classified material.

The accompanying table is compiled from a diagram showing the comparative density of traffic on double-track on the Southern Ry. during a 24-hour period in August, 1905. The freight trains include from 0 to 3 fast-freight, stock, fruit or vegetable trains in the several districts.

CANADIAN PACIFIC RY.—Our decision to double-track the section between Winnipeg and Fort William was scarcely brought about by the actual limit of the single-track having been reached. By increasing the siding accommodation, that is, lengthening the present passing tracks, and putting in additional side tracks so that trains might be started from terminals in pairs or triplets and so kept over the section, we might perhaps handle double or treble the number of trains we have ever had to handle; provided, of course, the facilities at divisional points were correspondingly increased, but under such conditions traffic would necessarily move more slowly. As you are no doubt aware, our traffic is not uniform the year around, but we have what we call the "fall rush," when the great western wheat crop has to be transported between the end of the threshing season and the close of lake navigation (70 days), a comparatively short period, involving a considerable problem in transportation which is often aggravated by untoward weather conditions. The physical nature of the road (a large amount of curvature) increases the risk in moving trains on single-track. With the double-track we will be able to push traffic over the road, will cheapen the handling of business by securing greater mileage out of engines and cars, and reduce delays and risk of accidents.

During our busy season, as before defined, we will have, say, three transcontinental passenger trains, one local train, three fast freight trains in each direction daily and on the Ignace Section (between Kenora and Ignace) we will probably run an average of 15 freight trains daily in each direction, or a total of 22 trains per day each way. What we have figured on taking east from Winnipeg during the crop movement this season is 400 cars per day, exclusive of passenger trains. The distance from Winnipeg to Fort William is 426.7 miles and is operated in three sections: Kenora Section, 132.8 miles; Ignace Section, 145.5 miles, and Fort William Section, 148.4 miles.

LEHIGH VALLEY RY.—As our road is a double-track one, in some cases four-track, we have had no regular solution of the problem as to when the increase of traffic would warrant double-tracking a single-track road.

In regard to the estimate of comparative cost of a double-track and a single-track line, and the cost of double-tracking a single line, I have never had any very authentic information on this, and have always considered that the relative cost would run exactly as you stated; roughly between 50 and 75% additional expense to double-track a single-track line. In a general way I have frequently assumed that a single-track line would cost 66% of a double-track line.

ILLINOIS CENTRAL RY.—The limiting and determining conditions which have led to double-tracking on the Illinois Central Ry. have been when the traffic has reached such a point that freight trains could not be moved without unreasonable delay. On our line between Fulton and Memphis, portions of which have recently been double tracked, we are handling trains as follows: (A) 18 regular freight trains in each direction; (B) 3 fast freight trains north and 5 trains south; (C) 6 passenger trains daily in each direction.

It is very difficult to figure in a general way on the comparative cost of a double-track and a single-track line, as the additional cost of the double track will be determined by actual conditions in every case. Our original lines in Illinois were constructed so long ago that no reliable figures are at hand to show the original cost as compared with the cost of double tracking, and our lines in the south, which have recently been double tracked, were originally constructed by other companies.

As stated above, the actual conditions will determine the percentage of double tracking as compared with the original construction. For instance, a mile of track on which the grading will average a 2-ft. embankment, and on which there are several trestles which would be duplicated in case the line is double tracked, will cost very much more in proportion than a line on which the work is very heavy. The grading for the second track on a mile such as described would run about 60% of the amount of material in the original embankment and the actual cost of the second track might run up as high as 90%. On the other hand, the excavating of 14 ft. extra for a second track in a 40-ft. cut with slopes 1½ to 1 would require the removal of only about 15% in addition to the amount of material which would have to be moved for a single track.

The additional cost of bridge and culvert construction will also vary in somewhat the same proportion. If trestles are used, the additional cost of the bridges would be approximately 100%, whereas the extension of 14 or 15 ft. on the end of a long arch culvert under a high embankment would, of course, be only a small percentage of the original cost.

We recently had occasion to make an estimate of what a single track would have cost in a case where we are making a double track diversion about four miles in length on which there is a cut 85 ft. in depth. We estimated that a single track would have cost $297,000, whereas the double track complete was figured at $400,000. This left $103,000 as the estimated cost of the second track, which is about 35% of the cost of the single track. On work not as heavy as this the percentage of cost of the second track would, as stated above, run a good deal higher, but I do not know of any method of arriving at any average percentage.

THE START OF CONSTRUCTION ON THE ERIE Railroad was commemorated by a monument dedicated, on Nov. 10, at Deposit, N. Y. The monument is set on the spot where the first shovel of earth for the construction of the Erie was dug.

A BOILER ACCIDENT caused two deaths in Washington, D. C., on the afternoon of Nov. 1. In the power house of the U. S. Electric Co., 14th and B Sts., a 28-in. steam header on a Babcock & Wilcox boiler burst, and blew two men up through the roof of the building. The section of piping in question had been in use for several years. The steam pressure at the time was not quite up to normal, 180 lbs., but it appears that water hammer occurred, which cracked a flange and caused the explosion. The plant was only slightly damaged.

HEAVY TRAFFIC ON A SINGLE TRACK was moved on the Peninsula Division of the Chicago & Northwestern Ry. during the 48 hours of Oct. 20 and 21, when a sleet storm had brought down all the telegraph wires and left the 464 miles of the division without telegraph service, so that no orders could be given by either the division superintendent or the train dispatchers. The train crews, however, managed to keep all the iron and copper mines supplied with cars and moved all trains practically on time. An official statement records that 4,971 cars were moved over the division on the two days, and that 125 freight trains and 34 passenger trains were handled on time, without accident, mishap or delay, and without the help of a train dispatcher.

THE TOTAL EXPENDITURES OF NEW YORK CITY for the year 1906 will be nearly $117,000,000. The total budget as adopted by the Board of Estimate and Apportionment on Oct. 31 is $116,805,490. This is an increase of about $7,000,000 over the appropriations for 1905. The largest items of this increase are for schools and for interest on the city debt, each of which amounts to over $1,350,000. Another additional million goes for increased expenditures in the Police and Fire Departments.

INCANDESCENT MANTLE GAS LAMPS for street lighting are to be substituted for electric arc lamps in the city of London.

PERSONALS.

Mr. G. U. Ryley has been appointed Land Commissioner of the Grand Trunk Pacific Ry., with headquarters at Montreal, Canada.

Mr. E. W. Clarke, M. Am. Soc. C. E., has been appointed Division Engineer, Division of Municipal Engineering, Isthmian Canal Commission.

Mr. S. D. Brooks has been appointed Superintendent and General Auditor of the Minnesota & North Wisconsin R. R., vice Mr. Geo. A. Keyes, resigned.

Mr. W. C. Hurst has been appointed Superintendent of the Detroit, Toledo & Ironton Ry., with headquarters at Springfield, O., vice Mr. J. C. Gleason, resigned.

Mr. W. J. Haynen has been appointed Master Mechanic for the Detroit, Toledo & Ironton Ry., with headquarters at Springfield, O., vice Mr. J. C. Homer, resigned.

Mr. J. B. Bassett, Junior U. S. Engineer, has been transferred from work on the Illinois and Mississippi Canal to Mississippi River work at Rock Island, Ill.

Mr. Robert McF. Doble, Consulting Engineer, of San Francisco, Cal., has severed his connection with the Abner Doble Co. in order to resume his individual practice.

Mr. Leroy Park, of 716 Mercantile Library Building, Cincinnati, has been appointed Assistant Engineer by the Isthmian Canal Commission for service on the Isthmus.

Mr. Leo E. Cranke, Engineer, U. S. Reclamation Service, has been transferred from the Milk River Project, Montana, to the Lower Yellowstone Project, Montana and North Dakota.

Mr. W. P. Hardesty, Assistant Engineer, U. S. Reclamation Service, heretofore with Mr. G. L. Swenden, Salt Lake City, Utah, has been detailed to Hazen, Nev., to assist in office duties.

Mr. Wm. Matthie has been appointed Superintendent of Terminals at Oelwein, Ia., for Chicago Great Western Ry., vice Mr. George Reith, resigned to accept service with another company.

Mr. H. P. Mobberly, formerly Assistant Engineer, Texas & Pacific Ry., has accepted the position of Chief Engineer for the Louisiana East & West R. R., with headquarters at Bunkie, La.

Mr. B. J. Dalton has been appointed Chief Engineer of the Denver, Enid & Gulf R. R., with headquarters at Enid, Okla. He succeeds Mr. W. D. Gerber, who has been assigned to other duties.

Mr. Geo. O. Sanford, Assistant Engineer, U. S. Reclamation Service, has been transferred from the North Dakota pumping projects to Glendive, Mont., for duty on the Lower Yellowstone Project.

Mr. N. D. Phelps has been appointed Sales Manager of the Mining, Crushing and Cement Machinery Department of the Power & Mining Machinery Co. to succeed Mr. T. H. Tracy, who has resigned.

Mr. P. H. Delano has been appointed Division Engineer in charge of construction on the Cincinnati Division of the Cleveland, Cincinnati, Chicago & St. Louis Ry. His headquarters will be at Middletown, O.

Mr. John E. Hill, Assoc. M. Am. Soc. C. E., Professor of Civil Engineering at Brown University, has had the degree of Doctor of Science conferred upon him by Rutgers College, of which institution he is a graduate.

Mr. H. D. Comstock, Engineering Aid, U. S. Reclamation Service, heretofore assigned to the Belle Fourche Project, South Dakota, will be transferred to the Washington office and assigned to duty in the computing section.

Mr. Orlando K. Morgan, of Boston, Mass., has resigned his position with the Road Department of the Massachusetts Electric Cos., and has accepted a position as Chief Draftsman with the South & Western Ry., at Bristol, Tenn.

Mr. A. M. Crain, who recently resigned his position as Engineering Aid in the U. S. Reclamation Service, has accepted a position as draftsman in the office of the Chief Engineer by the Baltimore & Ohio R. R., at Baltimore, Md.

Mr. G. W. Chance has resigned his position as General Manager of the Traction Company of America, Drexel Building, Philadelphia, Pa., and will take up a consulting practice in steam or electric railroad construction or operation, more particularly preferably for steam-electric road work.

Mr. W. S. Harer has been appointed Division Engineer of the Idaho Division of the Oregon Short Line R. R., to succeed Mr. J. P. Congdon, who has been appointed Supervising Engineer over work coming under the Chief Engineer on operated lines of that railroad.

Mr. John Anderson, formerly the senior partner of the well-known contracting firm of Anderson & Barr, of Jersey City, N. J., who retired from business several years ago and has been residing in Stockholm, Sweden, is paying a brief visit to the United States, and expects a few months later to return to this country permanently.

Mr. P. F. McDonald has been appointed Road Master of the South & Western Ry., with jurisdiction from Johnson City, Tenn., to the end of the track. Mr. McDonald will also have charge of all new track-laying southward from the present end of track near Toe River bridge. His office will be at Johnson City, Tenn.

Mr. H. W. Woodcock has resigned his position as Assistant General Superintendent of the Brooklyn Grade Crossing Commission and has entered into partnership with Mr. Edwin C. Swezey, under the firm name of Swezey & Woodcock, and will engage in a general engineering and surveying practice, with offices at 259 52d St., Brooklyn, N. Y.

Mr. W. S. Menden has been appointed Chief Engineer of the Brooklyn Rapid Transit Ry., of Brooklyn, N. Y., to succeed Mr. Eugene Klapp, M. Am. Soc. C. E., who has resigned to enter business with Mr. William B. Parsons. Mr. Menden has for some time been Chief Engi-

neer and General Superintendent of the Metropolitan Westside Elevated Ry. of Chicago, Ill.

Mr. E. P. Dawley has been appointed Engineer of Construction of the New York, New Haven & Hartford R. R., with headquarters at New Haven, Conn., and the office of Assistant Chief Engineer has been abolished. Mr. W. J. Black has been appointed Engineer, Maintenance of Way of the above road, with office at New Haven, Conn., and the office of Principal Assistant Engineer has been abolished.

Mr. F. E. Baxter, M. Am. Soc. C. E., has resigned his position as Division Engineer, Denver & Rio Grande R. R., with headquarters at Salt Lake City, to go into the contracting business under the firm name of Baxter, Straw & Storrs Construction Co., with offices at 420 D. F. Walker Building, Salt Lake City. Mr. C. A. Blake, heretofore Assistant Engineer, has been appointed Division Engineer to succeed Mr. Baxter.

Mr. Robert E. Jennings, of Jersey City, N. J., has been elected President of the Taylor Iron & Steel Co., High Bridge, N. J., succeeding Mr. Lewis H. Taylor, resigned. The latter had been President and Director of the Taylor Iron Works and the Taylor Iron & Steel Co. since the former company was organized in 1868. Mr. Percival Chrystie was elected vice-President to succeed Mr. Jennings and Mr. Knox Taylor was elected General Manager.

Mr. A. P. Valentine, Jr., Architect, Philadelphia, Pa., for the past six years connected with the government service at the U. S. Navy Yard, League Island, Pa., has resigned therefrom to accept the position of Assistant Structural Engineer in the Bureau of Building Inspection, Philadelphia, Pa. This, and other recent appointments in that bureau, have been made as the result of open competitive examinations conducted by the reorganized Civil Service Examining Board of the municipality.

Mr. Calvin W. Hendrick, M. Am. Soc. C. E., has been appointed Chief Engineer of the Sewerage Commission of Baltimore, Md. Mr. Hendrick was born in Paducah, Ky., in 1865, and when 16 years old he began work on the engineering corps of the Chesapeake & Ohio Southwestern Ry. Two years later he became a transitman and inspector of pavements in Louisville, where he remained until 1887, when he received an appointment as Assistant Engineer on the construction of the Georgia Southern & Florida Ry. He was City Engineer of Macon, Ga., from 1888 to 1894, and from 1895 to 1898 he was an Assistant Engineer on the staff of Mr. William Barclay Parsons, preparing plans for the Rapid Transit Railroad Commission. Later he was appointed Engineer of Sewers for the Rapid Transit Commission, holding this position at the time of his Baltimore appointment.

Mr. M. J. Caples, General Manager and Chief Engineer, South & Western Ry., Lick Creek & Lake Erie Ry., and Carolina Co., has issued a circular under date of Nov. 2, announcing the following appointments, effective upon the dates mentioned:

Mr. Wm. A. Hankins, Principal Locating Engineer, Sept. 1, 1905, with office at Bristol, Tenn.

Mr. A. W. Jones, Division Engineer, First Division, Elkhorn, Ky., to Fink, Va., Sept. 25, 1905, with office at Fink, Va.

Mr. Wm. Palmer, Division Engineer, Second Division, from Fink, Va., to North Fork of Holston River, Sept. 25, 1905, with office at Clinchport, Va.

Mr. Ward Crosby, Division Engineer, Third Division, North Fork of Holston River to Erwin, Tenn., Oct. 8, 1905, with office at Lovedale, Tenn.

Mr. Chas. L. Ruffin, Division Engineer, Fourth Division, from Erwin to Spruce Pine, Nov. 1, 1905, with office at Erwin, Tenn.

Mr. C. O. Vandevanter, Division Engineer, Fifth Division, Spruce Pine to Catawba River, Sept. 22, 1905, with office at Spruce Pine, N. C.

Mr. S. P. Daniel, Division Engineer, Sixth Division, from Catawba River to Spartanburg, S. C., Oct. 26, 1905, with office at Rutherfordton, N. C.

Obituary.

Col. Stephen V. Shipman, a well known architect of Chicago, Ill., died Nov. 13. He designed many public buildings in the West and Northwest.

Beauchamp H. Smith, second vice-President of the S. Morgan Smith Co., of York, Pa., died Nov. 1 at his home in Los Angeles, aged 36 years. Mr. Smith went to Los Angeles about five years ago for the benefit of his health, since which time he has resided there.

W. B. Bogardus, Assoc. M. Am. Soc. M. E., President and Chief Engineer of the Peninsular Engineering & Construction Co., of Jackson, Mich., died Nov. 1 at Spokane, Wash., from a complication of diseases affecting the kidneys. He was graduated from the Mechanical Engineering Department of Sibley College, Cornell University, in 1896, and since that time has made a specialty of the construction of Portland cement mills. He was buried in Buffalo, N. Y., his former home. He was 32 years old.

David Maxson Greene, M. Am. Soc. C. E., a consulting engineer with offices in Troy, N. Y., died Nov. 9 at his summer home in Adams, N. Y. A brief outline of his career is as follows: Graduated Rensselaer Polytechnic Institute (C. E.), 1851; Instructor Rensselaer Polytechnic Institute, 1851-1852; Assistant Engineer, enlargement of Erie Canal, 1852-1853; on railroad work in Ohio and Indiana, 1853-1854; Professor Geodesy and Topographical Drawing, Rensselaer Polytechnic Institute, 1855-1861; Director of that institution, 1878-1891; in Corps Engineers, U. S. N., 1861-1869; since then in general engineering practice; Division Engineer and Deputy New York State Engineer, 1874-1878. From 1872 to 1893 he was Colonel of Engineers, New York State National Guard. He was born in Brunswick, N. Y., in 1832.

ENGINEERING SOCIETIES.

COMING MEETINGS.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 16, 17. Annual general meeting at New York, N. Y. Secy., Wm. J. Baxter, 12 West 31st St., New York, N. Y.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.
Nov. 21. Annual convention at St. Louis, Mo. Secy., G. P. Conard, 24 Park Place, New York, N. Y.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 4 and 5. Annual meeting at New York, N. Y. Secy., W. H. Ross, 258 Broadway, New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 5-8. Annual meeting at New York, N. Y. Secy., F. R. Hutton, 12 West 31st St., New York.

MICHIGAN ENGINEERING SOCIETY.
Jan. 9, 10, 1906. Annual convention at Lansing, Mich. Secy., F. Hodgman, Climax, Mich.

NATIONAL ASSOCIATION OF CEMENT USERS.
Jan. 9 to 12, 1906. Annual convention at Milwaukee, Wis. Secy., C. C. Brown, Commercial Club Bldg., Indianapolis, Ind.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Jan. 10. Annual meeting. Secy., Willard Kent, Narragansett Pier, R. I.

INDIANA ENGINEERING SOCIETY.
Jan. 12, 13, 14. Annual meeting at Indianapolis, Ind. Secy., C. C. Brown, Commercial Club Building, Indianapolis, Ind.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 17, 18, 19. Annual meeting at Rockford, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Feb. 21. Annual meeting at South Bethlehem, Pa. Secy., R. W. Raymond, 99 John St., New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The headquarters during the coming annual meeting of the society, instead of being at the society house, 12 West 31st St., as in previous years, will be at the Edison Building, 44 West 27th St., New York City, the two upper floors being used. The opening session, at which President John R. Freeman will present the annual address, will take place there on Tuesday evening, Dec. 5. The second or business session will be held Wednesday morning, Dec. 6, in the main saloon of the steamship "Amerika" at the docks of the Hamburg-American Line, Hoboken, N. J. Following this session a special train will take those desiring to make the excursion to the new Henry R. Worthington Hydraulic Works at Harrison, N. J. On the evening of the same day there will be an illustrated lecture at headquarters by Prof. R. W. Wood, of Johns Hopkins University, on "Photography of Invisible Phenomena." The third session, Thursday morning, will include, besides the presentation of professional papers, a discussion on the subject "Bearings." In the afternoon there will be a reception at the New York School of Automobile Engineers, 146 West 56th St. The usual reception at Sherry's will occur on Thursday evening. The closing session will be on Friday morning and will be devoted to the presentation of professional papers.

CONNECTICUT SANITARY CONFERENCE.—The third annual sanitary conference of health officials of Connecticut will be held under the auspices of the State Board of Health in the Chamber of Commerce Hall, 763 Chapel St., New Haven, Conn., on Dec. 7 and 8, 1905. Three sessions will be held, the first at 8 p m., Thursday, Dec. 7, and the other two at 9.30 a. m. and 2.30 p. m., Dec. 8. Up to the present seven papers have been scheduled: "The Common House Fly in Its Relation to the Public Health," by H. E. Britton, State Entomologist, New Haven; "The Restriction of Contagious Diseases in Cities," by Dr. C. V. Chapin, Superintendent of Health, Providence, R. I.; "Animals as Carriers of Human Diseases," by Prof. W. H. Brewer, President of State Board of Health, New Haven; "Dissemination of Tuberculosis as Affected by Railway Travel," by Chas. B. Dudley, Chemist to Pennsylvania R. R., Altoona, Pa.; "Forms of Food Adulteration and their Relation to Public Health," by E. H. Jenkins, Director Agricultural Experiment Station, New Haven; "Medical Inspection of Schools," by Dr. E. K. Root, Member State Board of Health, Hartford; "Sanatorium Work," by Dr. J. P. C. Foster, New Haven. A local committee, headed by Prof. W. H. Brewer, is in charge of arrangements at New Haven.

NEW ENGLAND WATER-WORKS ASSOCIATION.—The meeting of the New England Water-Works Association, held in Boston on Nov. 8, was devoted to "The Present Relative Responsibility of Public Water Supplies and Other Factors in the Causation of Typhoid Fever." A paper with that title, prepared by Profs. Wm. T. Sedgwick and C-E. A. Winslow, of the Massachusetts Institute of Technology, was read by Prof. Sedgwick and was supplemented by a description of a typhoid epidemic spread in an unusual way, by Mr. E. E. Lochridge, engineer of the Springfield, Mass., water department, and Dr. Magrath, acting secretary of the Massachusetts State Board of Health.

In the paper it was stated that in our American cities having polluted water supplies the typhoid fever death rates range about from 30 to 125 per 100,000, while in those whose water supplies are unpolluted this rate is in general from 20 to 30, averaging about 25. Any rate over 25 may generally be considered as the tax paid for an impure water supply. The most severe arraignment of the Philadelphia political "machine" was that the needless delay in completing the filter system and putting it in operation has cost about 1,200 deaths from typhoid which would not have occurred had the water supply been properly filtered.

With the extension in the use of filtration systems and with changes from foul to unpolluted water supplies the relative importance of water as the vehicle of typhoid fever is decreasing and will continue to decrease. Nevertheless, with the possibility of contamination of any untreated water supply, the responsibility resting upon the officers in charge of such a supply must always be great.

In Massachusetts, where the State Board of Health has exercised a supervision over the quality of water supplies for so long a time, it may be stated that the water of any public supply may be drunk with safety; yet even here the typhoid death rates range in general from 15 to 25 per 100,000, while in England and Germany they range from 8 to 15. The excess of say 10 unnecessary deaths represents about 100 unnecessary cases of typhoid for each 100,000 of the population.

Among the more common paths for the propagation of typhoid other than water supplies are milk, shellfish, and celery or other vegetables which are not cooked. Typhoid may be prevalent in two ways: First a large number of cases may occur at the same time, and may therefore be attributed to a common source; and the disease is said to be epidemic; or the cases may occur without regularity and without indications of a common method of transmitting the disease; the term prosodemic is suggested to describe this condition. In dirty surroundings, typhoid is essentially a contagious disease. It needs only a case of "walking typhoid" to supply the germs, and the alliterative path Filth, Fingers (or flies), Food, offers a ready means for their spread, more or less directly, giving prosodemic typhoid.

An epidemic of typhoid in Springfield described by Mr. Lochridge and Dr. Magrath furnishes a most interesting example of the roundabout paths by which the disease may be transmitted. The epidemic first became noticeable about July 15 of this year. Springfield has a water supply which is notoriously unpleasant during the hot weather. When the epidemic was discovered, the local board of health charged it as a matter of course to the water supply, and said there was nothing for them to do. The officials of the water department, however, while not proud of their water supply, claimed that whereas it was rendered unpleasant by growth of algae which they could not control, it was not infected by disease, since they could and did prevent such pollution. They therefore instituted a study of the epidemic, in which they were assisted by the State Board of Health.

About two weeks after the epidemic was noticed the source of the water supply was changed, the reservoir in which the alga growths were greatest being shut off, and other sources drawn upon, the water receiving very little storage. This change, however, had no effect on the progress of the epidemic. Moreover, the distribution of cases as plotted upon the map did not correspond in any way with the water distribution. It was, therefore, believed that the source was to be found in some other medium.

It soon appeared that about the only circumstance which the first cases had in common was the character of their surroundings—they all living in the poorest and dirtiest part of the city, and being mostly Russian Jews, Syrians, etc. Their surroundings in general were very foul. After further study it seemed proven that the disease had been communicated by handling by customers with contaminated fingers, fruit or vegetables in making selections from a huckster's cart, these having subsequently been sold to other parties and eaten uncorked and without cleaning.

Later the epidemic began to spread into better families. In its first spreading out it could be traced along the routes usually followed by the push-cart peddlers, who supplied, to a certain extent, families somewhat more well-to-do than themselves. Some members of these families were perhaps employed in families still higher in the social scale, and might perhaps return from visiting their relatives or friends who might be sick with typhoid, to prepare the food for the families in which they were employed. Although it is obviously impossible to produce direct evidence of the correctness of this hypothesis, the chain of circumstantial evidence seems to be complete, and indeed there seems to be no other possible explanation of this epidemic.

ENGINEERING LITERATURE

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REVIEWS.

Cost Data.

Reviewed by Daniel J. Hauer.*

HANDBOOK OF COST DATA FOR CONTRACTORS AND ENGINEERS.—A Reference Book Giving Methods of Construction and Actual Costs of Materials and Labor on Numerous Engineering Works. By Halbert P. Gillette, Consulting Engineer, M. Am. Soc. C. E., M. Am. Inst. M. E., Late Associate Editor Engineering News. New York: Myron C. Clark. Morocco; 4¼ × 6¾ ins.; pp. 610; 30 figures in the text, and numerous tables. $4, net.

In the last decade, through the efforts of the Engineering News and several other technical journals, there has been an awakened interest among engineers and contractors in the detail cost of construction work. Engineers find such information essential in estimating the cost of proposed work, while contractors find these data necessary in making intelligent proposals on jobs and in systematizing their work. The basis of all successful systems and organizations for carrying on work of any kind is founded upon the cost of each detail. A successful business can be built up by exceptional individuals without this kind of information, but any competent man with such knowledge at hand can evolve a system of carrying on construction work, while those who have made a success without such data will effect great savings and make their success more pronounced with it.

In view of these facts a book on this subject is of especial interest, and such is Mr. Gillette's Handbook of Cost Data. The reviewer believes this to be the first handbook on the cost of engineering work that has been published. Morris, Trautwine and others have touched upon such matters in their writings, but owing to several reasons that need not be mentioned here the data given by them, although it possesses certain value, is of little practical use. Mr. Gillette has already written several treatises on the cost of particular features or kinds of engineering work, but in his present book he attempts to cover as nearly as possible all classes of construction, and present it in such a manner as to allow of its application by both the engineer and the contractor.

The book is divided into fourteen sections, under heads that facilitate quick reference. In his preface, the author writes of the difference between a contract price and a contract cost, which have heretofore been considered by many of the profession as identical; and shows that in order to analyze costs it is necessary to know the methods used in construction and operation and the local conditions.

Section one treats of preparing estimates, cost keeping, and its corollary, the organization of forces. Although there is much in this section that seems elementary, yet the entire chapter is valuable, for no doubt this book will find a greater use among the younger engineers and contractors than those of long experience. Mr. Gillette discusses the keeping of detail costs, and shows various ways of arriving at such costs and systems of recording them. He also points out the great use of such data in enlarging the output of work, in systematizing construction and in handling men. The subject of engineer's estimates is dealt with, and twenty reasons are enumerated why engineers so frequently underestimate the cost of work, the principal ones being:

Students of engineering are seldom trained in the art of cost estimating, but left to acquire that art, haphazard after graduation.

A subsurface survey is frequently not made, and, as a consequence, unexpected materials are encountered in excavating.

A study of the sources of local materials, their suitability for the work, and their unit cost delivered, is often not made, and, as a result, specifications are frequently drawn that cannot be lived up to except by importing materials at great expense.

Interest and depreciation of plant, and the percentage for profits are usually underestimated.

Changes in the alinement or in the design, made after contracts have been awarded, may result in large claims for extra compensation.

Rates of wages and prices of materials may rise; and if the work is large, the work itself may be the cause of such increases.

Limiting competition by the drawing of unfair or indefinite specifications is a common cause of high bidding prices. Severe interpretation of indefinite clauses often causes failure of contracting firms, and the history of such failures operates to limit subsequent competition and raise prices.

A word is said advocating uniformity in units of measurement and on the subletting of work Contract vs. Day Labor work is touched upon, the author showing conclusively that contract work is the ideal system of doing all classes of contruction. The section closes with a set of useful instructions to foremen and hints to contractors. The latter were a series of editorials published in the Construction News Supplement of the Engineering News a little more than a year ago, when Mr. Gillette was associate editor of that journal. These hints were so excellent that many of those who read them will no doubt be pleased to learn that they have been put into more lasting form.

Sections two and three deal respectively with earth and rock excavation, being a synopsis and condensation of the author's books; "Earthwork and Its Cost," and "Rock Excavation—Methods and Cost," both of which have been reviewed in these columns (July 16, 1903, and Nov. 17, 1904, respectively).

In section four the cost of roads, pavements and walks is analyzed. Macadam and Telford roads, the various kinds of pavement, curbs, gutters and walks are discussed and their detail costs set forth.

In the next section stone masonry is taken up. Statistics are given on the percentage of mortar used in various classes of masonry. The cost of dressing and sawing stone and also of laying masonry is given, besides some records of the cost of plug drilling by hand and pneumatic process. A very interesting description of slope wall work is embodied in this section and the method of its construction and the details of its cost are given.

Section six is headed the Cost of Concrete Construction of All Kinds, and is by far the largest section, the subject being treated in the most exhaustive manner. Within the last two or three years much has appeared in print on concrete, both plain and reinforced, and some cost data, but this is the first to appear that gives such information as is needed to estimate the cost of future work of various kinds. The author first takes up the subject of voids and quantities of the ingredients of concrete and presents some new views, based upon his own experience. Then he enters into a discussion of the cost of sand, stone and gravel, the mixing, handling and placing of concrete, and the cost of forms. This is considered both in mixing by hand and machine. In writing of the cost of forms, Mr. Gillette points out that records of these costs should be kept both by the cubic yard, which is commonly done, and by the thousand feet board measure of lumber used. This is a highly important matter, and it is singular that it has not been commented on before. Under the subject of forms the author has much to say that will be found of interest to both contractors and engineers. There is no doubt that the future use of concrete depends very much on the cost of forms, so too much importance cannot be given to the subject. A hundred pages are devoted to the cost of various classes of concrete work.

Sections seven and eight are devoted to the cost of water-works, sewers, vitrified conduits and tile drains; in other words, construction that embraces trench digging. Although trench digging is common, especially in cities, there are but few data on it. The work is generally accompanied by so many risks and difficulties that it is extremely hard to give rules for estimating its cost, but all that Mr. Gillette has to say regarding it will be found useful.

Sections nine and ten relate to structures in which timber dominates, such as foundations, trestles, wharves, docks and buildings. Pile work, including concrete piles, are dealt with, and under buildings, brick, stone work and the cost of mill construction are discussed.

Under steam and electric railways, in section eleven, tracklaying, ballasting and the erection of trolley poles are taken up, and some costs of building logging roads are given. In section twelve the erection and painting of steel bridges is examined, and many examples of cost of such work cited. In section thirteen the cost of railway and topographic surveys is set forth, and lists of rations and supplies for camping purposes given. In section fourteen is recorded the cost of many miscellaneous structures, such as fences, revetments, clearing land, some asphalt work, bridge foundations, sodding, etc.

Throughout the entire book many records of costs are copied from engineering journals, and many of the author's own writings from the Engineering News are quoted, all of which is duly noted. Credit is also given to many engineers and contractors for furnishing information relative to costs of work done under them.

The book abounds with numerous examples of cost data and short descriptions of work, and is illustrated with cuts, wherever they add to the text. The subject is presented in an attractive manner. Although much information is given, yet the users of the book will desire more. This is but natural, as it is really the genesis of such books. No doubt future editions will be added to and improved, and it is to be hoped that Mr. Gillette will give us additional works in his chosen field. Engineers and contractors, both young and old, will read the Handbook of Cost Data, and its usefulness will only be limited by its sale.

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The Crystallization of Iron and Steel.

Reviewed by Bradley Stoughton.*

THE CRYSTALLIZATION OF IRON AND STEEL.—An Introduction to the Study of Metallography. By J. W. Mellor, D. Sc. London, New York and Bombay: Longmans, Green & Co. Cloth; 5 x 8 ins.; pp. 144; 65 figures, partly in the text. $1.60, net.

In the lay mind the crystallization of iron and steel has little meaning. Even in circles in which the science of metallography is valued, if not understood, the true significance of the crystalline structure of metals is not always recognized. The man who tempers steel and the blacksmith know that high-carbon steel having a "crystalline" or "fiery" fracture is unfit for their uses, and they call this "crystalline steel." If the fracture is "sappy" or "silky," they call the material "non-crystalline steel," and this term is synonymous in their minds with high quality. To tell these men, and many others who have learned what they know of steel from shop practice, that the most silky of the high-carbon steels has as well-defined a crystalline structure as granite would merely render one liable to be disbelieved. A knowledge of crystallization will often reveal the causes of good, as well as bad, quality in steel, and even in cast iron; will explain many hitherto mysterious failures in service, not only of the high carbon tool steels but of the soft boiler-plates and structural material; will lead, and has led, to the discovery of new kinds of steel; will improve our methods of manufacture, of tempering and of annealing, and will explain that mystery of ages, the hardening of steel by rapid cooling from a red heat. A proper crystalline structure in all steels is important, and in many steels is as important as proper chemical proportions.

The study of the physical properties and structure of metals is called metallography, and, because the structure of metals is usually very minute, it is examined usually with the aid of the microscope, so that branch of the science known as microscopic metallography is the one which is attracting the largest share of attention at the present time. This science is of very recent origin. Starting from three separate and independent sources† it grew slowly until two papers by Sorby, in 1886 and 1887,‡ before the Iron and Steel Institute, aroused great interest. From microscopic examination of iron and steel the science spread to the study of other metals and alloys in the same way. At the present time there is hardly a large steel works in the United States, and only a few in England and Europe, which has not a well-equipped department of microscopic metallography, and the practical usefulness of the art increases constantly. A book which brings this knowledge within the reach of anyone who cares to grasp it is most welcome, and seems to be present in Dr. Mellor's little volume.

The book includes six lectures delivered to the engineering students of the Staffordshire County Technical classes at the Newcastle High School, in November, 1904, and is intended to summarize the results of the more important researches which have been made during the last ten years upon the constitution of the alloys of iron and steel. It is divided into six chapters, corresponding to the six lectures, and having the following titles: The Solidification and Cooling of Alloys, The Constituents of Iron and Steel, The Hardening, Annealing and Tempering of Steel, The Crystallization of Iron and Steel, The Influence of Stress and Strain, How to Prepare a Specimen for the Microscope, to which has been added, as an appendix, what is practically a reprint of the glossary adopted by the Committee of the Iron and Steel Institute on the Nomenclature of Metallography. An index adds to the value of the publication.

In the first lecture the author takes up and explains the modern theory of metallic solutions as an introduction to the second, which extends the subject to a discussion of the solutions of carbon in iron. This second chapter is the only unsatisfactory one of the book. Confining himself to limited space, the writer has sacrificed conciseness to mere brevity. Instead of selecting a few important and necessary facts and concentrating the reader's attention on them, he has introduced many facts and explained them in too brief a fashion to make them all readily comprehensible. Throughout this chapter there is constant confusion between the liquid and solid solutions of carbon and iron, two very different alloys, between which a distinction is nowhere clearly indicated. On pages 23 and 30 the author speaks of the eutectic of iron and carbon. In the one place he means the eutectic, the most soluble of the liquid alloys (4.3% carbon), in the other he means the eutectoid, the most soluble of the solid solutions (0.90% carbon). A few words of explanation on page 23 would have resulted in a great saving of the reader's time. In his discussion of martensite, austenite, etc., the author ignores the recent French theories of the nature of these constituents, although the bulk of our evidence would indicate that they are the ones most nearly in accord with the known facts, besides being the easiest to understand.

From the discussion of the constituents, the text passes easily and naturally to the questions of hardening, annealing and tempering. The various theories are discussed clearly and fairly. Two errors have crept in which it is well to note. On pages 60 and 61 the author says:

> The metal is annealed by heating it to the Ac_1 critical point, and keeping it at that temperature a sufficient length of time to change the "hardening carbon" to "cement carbon," and the hard into soft allotropic iron. When the effects of hardening have been removed by heating the steel to the Ac_1 point—it is quite immaterial whether the steel be slowly or quickly cooled—the metal will be annealed.
>
> At Ac_1 the brake appears to be sufficiently relaxed to allow the whole of B to pass into A.

The brake action of passive resistance is relaxed completely 200° below Ac_1, and, for mere annealing, it is not necessary to heat to that temperature. The fact that almost all annealing is conducted near Ac_1 is because the operator desires to obtain not only an annealing, but also a restoring, of the grain size to the finest possible. For this reason annealing is accomplished by heating slightly *above* Ac_1, and the change that takes place is from cement carbon to hardening carbon (not the reverse). It is then very material that cooling be slow, lest the metal be hardened. Even in the method stated by the author cooling must be slow, for Ac_1 is not a point, but a range of temperatures, and to heat to the stated Ac_1 would carry the metal part way into the range, where the carbon changes to the hardening form.

The next chapter explains the overheating and burning of steel, the embrittling effect of phosphorus, etc., by the formation of brittle envelopes, or intergranular networks, and the refining or restoring of grain size by heat and mechanical treatment, a subject so important to the welder, toolmaker and roller of steel, and one which is already promoting changes in the rolling of railroad rails and other shapes. For blacksmiths and chain-makers this chapter is a special lesson.

The fifth chapter includes practically all of the known facts as to the plastic yielding and fracture of the ferrous metals. The sixth, and last, chapter is the best collection in any one book of the methods of preparing specimens for microscopic examination.

The two predominant features of the book as a whole are the great concentration of information into a small space, and the interesting manner in which it is presented, which latter never fails to attract. The concentration is not always an advantage, because it sometimes interferes with an easy grasp of the writer's meaning, especially by one to whom the subject is new, and it is for this class particularly that the book is suitable, since it does not pretend to extend the realm of known facts, but only to collect them from scattered sources into one volume. A few examples of this fault have been mentioned already. On pages 50 and 51 the writer confuses malleable cast iron with gray cast iron, and temper carbon with graphitic carbon. A little more space devoted to drawing a clear comparison between the two would have been very profitable. On page 18 the description of the solidification of copper-silver alloys is difficultly understood even by one to whom the facts are already familiar, and on page 80 the author discusses the effect of different elements on pig iron and steel, but does not state when he is referring to pig iron and when to steel, so that his statements are either meaningless or erroneous. On page 69 there is confusion between the words copper and gold, which renders the last part of the first paragraph absurd. This may be due to two typographical errors.

There is this objection to the printing of lecture courses: What may be explained very clearly by a speaker, with the aid of diagrams and a pointer, may be difficult to understand when expressed in the same words in print. In rearranging these lectures for publication an extension of the explanations, in the second chapter especially, would have added to the value of the book, while certain subjects might have been omitted, such as the discussion of the Phase Rule, which is not of any particular benefit to one who does not expect to delve deeply into the study of alloys. A similar example is the section on copper-antimony alloys (page 20), which is not especially helpful in explaining the phenomena of the iron-carbon solutions. This clouding of the main issue by the introduction of data not absolutely necessary is one of the principal weaknesses of the book. The human mind, and especially the human memory, will absorb facts more readily through the eyes than the ears, and a lecture demonstration will often serve not only to fix the attention and interest, but to assist the audience in understanding and retaining a subtle explanation. A lecturer is thus sometimes justified in digressing slightly for the purpose of giving an active demonstration of some interesting phenomenon germane to the subject; not so the description of a demonstration in a book, for which the same excuse does not exist, nor the presentation of information which does not carry forward the same line of thought.

The writer gives many references in the text which are, for the most part, complete and well selected. A notable exception is (p. 15) where he says:

> It is supposed that the presence of many foreign substances, like carbon, nickel, and manganese, augment the passive resistance so as to render the hard γ-iron more stable and permanent at low temperatures. On the other hand, the presence of chromium, tungsten, aluminium, silicon, phosphorus, arsenic, and sulphur facilitate the passage of the hard beta-iron to the soft alpha-iron.

These statements will be questioned by some, and it is unfortunate that their source is not indicated.

When all has been said, this book is the best popular introduction to the study of metallography that we have, and is recommended to those who would learn the science, as well as to any of a scientific turn of mind who care to spend a few hours in profitable entertainment.

PROFESSIONAL PAPERS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 9 x 11¼ ins.

No. 42: Geology of the Tonopah Mining District, Nevada. By Josiah Edward Spurr. Pp. 295; 24 plates and 78 text illustrations.

To those interested in the Tonopah gold and silver mines this large monograph should prove valuable.

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†H. C. Sorby, "On a New Method of Illustrating the Structure of Various Kinds of Steel by Nature Printing," Sheffield Literary and Philosophical Society, February, 1864.
"On the Microscopical Photographs of Various Kinds of Iron and Steel," British Association Report, Part 11, 1864, p. 189.
D. C. Tschernoff, "Remarks on the Manufacture of Steel and the Mode of Working It." Imperial Russian Technical Society, April and May, 1868. Translated into English by William Anderson; London, 1880.
"Structure of Cast Steel Ingots." Imperial Russian Technical Society, December, 1878. Translated into English in Proceedings, Institute of Mechanical Engineers, January, 1880. Translated into French in Revue Universelle des Mines, Second series, Vol. 2, 1880, p. 140.
A. Martens, "On the Microscopical Examination of Iron." Zeitschrift des Vereins deutscher Ingeneure, Vol. XXI, 1878, pp. 11, 205, 481; Vol. XXIV, 1880, p. 397. Translated in Engineering, Vol. XXVIII, p. 88.

‡H. C. Sorby, "On the Microscopical Structure of Iron and Study of Microscopical Structures of Steel." Journal, Iron and Steel Institute, No. 1, 1886, pp. 140-4.
"On the Microscopical Structures of Iron and Steel." Journal, Iron and Steel Institute, No. 1, 1887, pp. 255-288.

Field Geology.

Reviewed by N. S. Shaler.*

STRUCTURAL AND FIELD GEOLOGY.—For Students of Pure and Applied Science. By James Geikie, LL. D., D. C. L., F. R. S., Etc., Murchison Professor of Geology and Mineralogy in the University of Edinburgh, Author of "The Great Ice Age," "Prehistoric Europe," "Earth Sculpture," Etc. New York: D. Van Nostrand Co. Cloth; 6 x 9 ins.; pp. 435; 58 plates and 142 text illustrations. $4, net.

Nearly all the distinguished teachers of geology have written text-books, manuals, or principles. More than any other group of naturalists they feel the desire to perpetuate their methods of instruction and to set forth what seem to them the facts of their ample science which are most likely to help their successors in their novitiate stage. Looking over the ample list of these endeavors we see that they fall into two diverse groups: in the one, and unusually, the author combines with the matter which has served him in his teaching a wide range of facts of which he has only book knowledge, but which he thinks will enlarge the learning of the reader. In the other, and rarer, works—all too rare, indeed—we have a clear presentation of those details only which are personally known to the instructor and have been proved useful in his teaching, and which are thus shaped into coherent thought.

The first of the above-mentioned two classes of geological treatises, the semi-encyclopedic group, has for its type specimen, in its way admirable, the "Manual of Geology" of the late James D. Dana. In its ample store has been gathered what is, perhaps, the largest body of well-verified elementary facts to be found in any science. The trouble is that only a limited part of this wonderful agglomerate has ever been, or can be, digested by any one teacher, or is appropriable by a beginner in geologic science. James Hall wickedly said of it "that all the Lord had ever done was set forth in the book, but the Lord Himself alone knows where to find it." It is, in effect, a most valuable compendium of geology, especially for American students, helpful alike to the tyro and to the expert, but not fitted to lead the beginner swiftly and surely on his way into the science.

The second of these classes of beginner's books in geology has no other example so good as James Geikie's "Structural and Field Geology," which we are considering. Its excellences are simple and may be briefly set forth. The author has a clearly defined and limited purpose: this is to present so much of the science of geology as is needed to those who are to deal with its problems in the field as geological surveyors or as enquirers of any group of that wide profession of engineering who have to ground their work on the conditions of the earth. Even with this definite and what may, at first sight, appear to be rather narrow limitation the author has, notwithstanding his well-known skill as a writer, need for all the space afforded by his ample volume. The limits set to his task enable him to put aside problems of geological successions, the history of organic life in time, and the theories of geologic action and to limit himself to a plain account of what may be termed the statics rather than the dynamics of the earth, and of that division to so much only as is required by the surveyor or the engineer. Thus restricted, he deals with his subject in a way that may be briefly set forth as follows:

In the first chapter there is an admirable, brief account of the rock-forming minerals, all within the comprehension of students who have a very elementary knowledge of mineralogy; next we have a like brief but from the point of view sufficient account of the constitution of rocks, then a bare note concerning fossils, about a dozen pages, which serves no more than to tell the student that such things exist and that they may afford him valuable information. At the end of the first hundred pages the author enters upon his main task; thence on through the remaining nineteen chapters the aim is to show the pupil what the field should teach him. Nowhere else has the present writer found this work so well done as here. The author's extensive experience as an interpreter of the highly illustrative but difficult rocks of Great Britain, particularly of Scotland, and his long service as a successful teacher enable him to select the features which are likely to puzzle the student in the field. His text seems to provide for all such difficulties, making the provision in almost every instance from examples which are fairly typical of their several classes.

The selection of the abundant illustrations shows well the purpose of Professor Geikie in going directly to the facts for his evidence. Of the nearly threescore photographic plates, more than fifty are from nature, and though from the Scottish field are sufficiently characteristic to serve in the interpretation of any district where like structures are found. The abundant illustrations in the text exhibit few of the stereotyped text-book designs, little related to actual facts, which are so common in works of this general nature. By far the greater number of them are, though diagrammatic, evidently as they should be, composites from memory of actual occurrences. These features of the presentation add not a little to the sense of reality which eminently characterizes this work.

The text is admirably clear and vigorous, as is that of all the author's works: there is not a sentence in it which does not go straight to the point and this without being unpleasantly precise. Some of his fellow-islanders may be inclined to "go for him," because of his use of the word reliable in what they consider the American misuse when it means trustworthy; but this would be mere cavilling. More to the point is his occasional use of the term *vein* where a *dyke* is meant. It may be doubted whether many American geologists would speak of eruptive veins, including in the category such structures as protrusions of granite in masses extending into other rocks. The tolerably well-developed usage of this country, which limits the term vein to masses within walls in which the material has been apparently deposited from water, seems to the present writer more satisfactory.

As for the serious imperfections of the book, they are hard to find. We may question the sufficiency of the statements which do not give the reader an adequate idea of the coal deposits above the level of the carboniferous, but as it is not the author's purpose to give more than the most cursory glance at mineral resources, these and other like omissions are inevitable. Perhaps more serious is the mere cursory reference to coast lines, to which matter the last half page of the book is devoted. Thus a great field, rich in structural features of the utmost importance, lacks presentation, and the engineer who has to deal with problems concerning harbors or the winning of marshes to agriculture, lacks the good help he has found in other matters. These trifles are noted because it is the business of the critic to criticise. The work is excellent in plan, in presentation, and as a specimen of the bookmaker's art. It will be very helpful, not only to beginners, but to those who have been well-trained in the science of geology.

*Dean of the Lawrence Scientific School, Harvard University, Cambridge, Mass.

THE TANKING OF SEWAGE.—By F. Wallis Stoddart, F. I. C., F. C. S. Reprinted from the Journal of Preventive Medicine, September, 1905. Bristol, England: The author (Western Counties Laboratories). Paper; 7 x 10 ins.; pp. 20; one figure in the text.

Mr. Stoddart is known to some of our readers as having developed the variety of continuous or percolating filters that bears his name. He here reviews some experiments on the proper capacity of tanks for the preliminary treatment of sewage and gives his conclusions based thereon. As embodying these conclusions, in part, he shows a longitudinal section of a tank with submerged cross walls and with scum boards, and without either submerged inlets or outlets. He suggests a tank volume equal to 12 hours' average dry weather sewage flow, which he believes would be capable of handling a storm flow up to three times the dry weather flow. His reason for cutting down tank capacity, as compared with the usual British allowance for 24 hours' dry weather flow and over, is that the large capacities not only call for a needless capital outlay, but also give rise to putrefactive products which cause bad odors and clog filter beds. The outcome of the study is an illustration of "reversion to type," the type in this case being the ordinary settling tank.

Tools and Mechanical Practice.

Reviewed by William W. Bird.*

TOOLS FOR ENGINEERS AND WOODWORKERS.—Including Modern Instruments of Measurement. By Joseph Horner, A. M. I. Mech. E., Author of "Pattern Making," "Hoisting Machinery," etc., etc. London: Crosby Lockwood & Son. New York: D. Van Nostrand Co. Cloth; 5¼ x 8¼ ins.; pp. 340; 456 figures in the text. 9s.; American price, $3.50, net.

LEHRBUCH DER MECHANISCH-METALLURGISCHEN TECHNOLOGIE.—(Verarbeitung der Metalle auf Mechanischem Wege). By A. Ledebur, Professor in the Royal School of Mines at Freiberg, Saxony. Braunschweig, Germany: Friedrich Vieweg & Son. Paper; 6 x 9 ins.; pp. 805; 754 illustrations, mostly in the text. 18 marks; American price, $7.20.

MACHINE-SHOP TOOLS AND METHODS.—By W. S. Leonard, Instructor in Machine-Shop Practice and in Practical Machine Design, Michigan Agricultural College. Third Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9¼ ins.; pp. 554; 689 figures in the text. $4.

The book by Mr. Horner is devoted entirely to machinists' and woodworkers' tools and measuring instruments. The term engineer as used by him corresponds to our word machinist. The author has written a clear and comprehensive description of various groups of tools, such as cutting, scraping, percussive and molding, using language that will be readily understood by students and apprentices. Some valuable points are given in the use of these tools, including the proper angles for cutting and methods of grinding. The construction of the tools themselves, however, is not taken up and but few pages are devoted to hardening and tempering. As a purely descriptive work, the book is neatly gotten up, clearly printed and well written and illustrated.

The book by Professor Ledebur is a small library in itself and indicates a very comprehensive understanding, on the part of the author, of all the common metals, their production, uses and properties, together with the machinery and fixtures required for their proper handling. Part I., or about three-quarters of the book, is given up to seven chapters of descriptive matter on metals, alloys, minor tools, foundry practice, forging, rolling-mill machinery, machine tools, joining of metals and finishing of surfaces. Part II. consists of thirteen chapters on the manufacture of various metal articles, such as steel plates, wire, type, tubes, screws, cutlery, pins and locks.

A list of references on the subject matter is given at the end of each chapter and adds to the value of the work. The book is well illustrated and the description of shop methods is good and, in the frequent references to American practice, is up to date. The book as a whole is too extensive in its scope to be of value except as a reference work for students, as few people in this country care to own a book containing so much about so many things.

The book by Mr. Leonard represents his lectures on shop practice and machine design, given to the students in the Michigan Agricultural College. The text is concise, comprehensive, and clear, and the reader is at once convinced that the author has had an extensive shop experience and knows whereof he writes. The description of the machines and tools is good and covers the principal details without useless words. The names of the machine parts, tools and fixtures are those used in general shop practice, a statement which cannot be made with regard to most books which have been written by teachers. The illustrations are not in keeping with the rest of the book and should be improved in the next edition.

Numerous questions on the text are given at the end of the book, so that the reader may test his knowledge of the work if he is so disposed.

The book as a whole is undoubtedly the best one on machine shop practice that has yet appeared, and should be owned by all students and young machinists who desire a book on this subject: for them it contains much of value, but for the man of experience who is looking for something new and original it has but little to offer.

*Professor of Mechanical Engineering and Director of the Washburn Shops, Worcester Polytechnic Institute, Worcester, Mass.

Statically Indeterminate Bridge Stresses.

Reviewed by Henry S. Jacoby.*

THE STATICALLY-INDETERMINATE STRESSES IN FRAMES COMMONLY USED FOR BRIDGES.—By Isami Hiroi, C. E., Dr. Eg., Professor of Civil Engineering in the College of Engineering, Tokyo Imperial University. New York: D. Van Nostrand Co. Cloth; 5¼ x 8 ins.; pp. 174; 94 figures in the text. $2, net.

This book forms an important contribution to the literature of bridge engineering. It is the first attempt to present in the English language in a single volume the principal cases of statically indeterminate stresses occurring in the practice of the bridge engineer, the solution of which is based exclusively on the method of least work.

The fundamental principle of the method of work has been expressed by Castigliano in two theorems, as follows:

I. The displacement of the point of application of an external force acting on a body—caused by the elastic deformation of the latter—is equal to the first derivative of the work of resistance performed in the body, with respect to the force.

II. The partial derivatives of the work of resistance with respect to statically-indeterminate forces which are so chosen that the forces themselves perform no work are equal to zero.

In the introductory chapter the author, referring to the second theorem, known as the principle of least work, explains it to mean that the work of a system of forces, acting upon an elastic system of construction, will be the least possible that is necessary to maintain equilibrium; or that the external forces so adjust themselves as to develop internal stresses in the structure that will make the total work of resistance in the latter a minimum.

Chapters I. to VI. inclusive, refer, respectively, to the stresses in trussed beams, viaduct bents, continuous girders, arches with two hinges, and in suspension bridges and trusses with redundant members; while Chapter VII. deals with secondary stresses due to the rigidity of truss joints. These chapters contain 15, 20, 27, 39, 30, 15 and 21 pages, respectively. In each case the internal work is expressed in terms of the external forces and differentiated successively with respect to each force to be found. The expressions for the unknown forces are then deduced in a convenient form for use by the designer.

An essential feature of the book consists in the numerical examples that are worked out to illustrate the application of the formulas. Incidentally, it may be remarked that several formulas extend twice across the page although printed in small type. Indeed, without some of these examples, the difficulty in using the book would be vastly increased to all but the most capable designers who maintain their proficiency in theoretical investigation.

The first of the examples relates to the king-post trussed beam, and shows that the stress in the tie rods is 19% less than if the beam be assumed as continuous over three fixed supports and 5% greater than if assumed to consist of two discontinuous beams. The maximum fiber stresses in the beam under the same assumptions are respectively 13⅓ and 6% less than the value found by the method of least work. The queen-post trussed beam, and a beam reinforced by sloping struts and a straining beam, either with masonry or timber column supports, are also treated in the first chapter.

The forms of viaduct bents include those having the cross girder riveted between the columns; those having one panel of sway bracing; and those with knee braces only. The loading consists of either symmetrical or unsymmetrical live loads and wind loads.

The treatment of continuous girders includes the important case in which one or more supports of metallic columns are used, as well as the usual one in which all the supports are regarded as unyielding. Formulas are then deduced for the moments and reactions at the supports of a swing bridge with three supports, a swing bridge with four supports and partially continuous, and a double swing bridge with four supports.

Under arches with two hinges the general case of the arch rib is first considered, and in this connection a simplified formula is derived for the horizontal thrust due to two symmetrical loads, which equals double that for one load. This case is followed by the parabolic arch rib having its sectional area and moment of inertia vary as the secant of the inclination of the neutral axis; the circular arch rib with uniform cross sections; the flat parabolic and flat circular arch ribs, both with uniform cross section; the spandrel-braced arch; the balanced spandrel-braced arch having projecting cantilevers outside of the main span, that support simple truss approaches; and braced arches with horizontal ties between the end pins.

In every case formulas are deduced for the reactions due to vertical loads, temperature stresses, and for the displacement of supports. The numerical examples in this chapter include a circular arch rib with solid web and span of 250 ft., and a spandrel-braced arch of eight panels with a span of 120 ft. This is not the place to discuss the relative merits of the different methods employed in practice for the design of spandrel-braced arches, with respect to the amount of labor involved, the liability to error, etc., but it may be of interest to state that some years ago Prof. A. H. Fuller made a critical comparison of three methods and concluded in favor of the use of displacement diagrams and of influence lines in determining, respectively, the horizontal thrust and the stresses in the truss members.

The statement at the bottom of page 73 on neglecting the effect of axial stress in an arch rib should be accompanied by the caution that this can safely be allowed only for a fairly high rise say approximately one-fifth of the span. For a rise of only one-tenth of the span the effect of axial stress becomes too large to be neglected in careful designing. The percentage of error in the horizontal thrust is no measure of the resulting error in the stress of any member. This fact is recognized by the author on pages 99 and 104. As affecting spandrel-braced arches, the statement in the last sentence of Art. 64 ought not to be accepted without further qualification, as has been proved by experience.

The chapter on arches without hinges covers the same types of arch ribs with solid and open webs as in the preceding chapter and therefore needs no further comment.

The formulas for suspension bridges apply to the stiffened suspension bridge, and to the cable suspension bridge with continuous stiffening trusses. The former is treated as an inverted arch with two hinges, due consideration being given to the motion of supports caused by changes in the length of the inclined anchor ties. The entire treatment is condensed into ten pages. The same chapter contains five pages on trusses with redundant members, which the author characterizes as "the least important of all, considering the comparative rarity of the kinds of structures treated," and has therefore deemed it "sufficient merely to indicate the mode of procedure in the calculation of stresses by means of the method of work."

The method of finding the secondary stresses in a truss due to the rigidity of its joints is applied to a Warren truss of two panels each 30 ft. long and 20 ft. deep. The stresses per square inch range from 271 lbs. in a diagonal to 500 lbs. in the lower chord. The balance of the last chapter deals with secondary stresses in the posts of a bridge due to rigid floor beam connections and sway bracing, both for live loads and wind pressure. Two types of sway bracing are used: the lattice girder and the single rectangular panel with two diagonal ties. The deduction of the necessary formulas for the moments at the post connections for vertical loading, and of the location of the points of inflection in the posts for wind loads, form very interesting illustrations of the application of the method of least work.

Only those who have attempted similar work can fully appreciate the immense amount of painstaking labor required in the preparation of such a text, and the necessary special facility in the use of calculus and mechanics as well as algebraic analysis. The author's familiarity with the literature of bridge stresses and design is evident.

Apart from slight infelicities of expression by the occasional omission of the article a, an, or the, the author is to be congratulated upon the good English employed in the text. The notation is simple and easily remembered. The contents show that no labor has been spared to reduce the volume of the text to very moderate limits, and to secure accuracy in the composition. It is to be regretted that there is no index, but this lack is made up in part by a very complete table of contents. The publishers have done their work well. It is possible to read every subscript and exponent in the smallest type employed. The only adverse criticism on the physical make-up of the book relates to a minor blemish caused by the large type on the back of the cover. The book deserves a place in the library of every bridge engineer.

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ADVANCED MECHANICAL DRAWING.—A Text for Engineering Students. By Alpha Pierce Jamison, M. E. Assistant Professor of Mechanical Drawing in Purdue University. New York: John Wiley & Sons. pp. 177; 27 plates and 108 text figures. $2.

The present volume practically forms Part II. of Mr. Jamison's series on Mechanical Drawing. Part I., "A Course in Elementary Mechanical Drawing," was reviewed in these pages under date of Dec. 15, 1904. The "Advanced Mechanical Drawing" is intended for the Sophomore class as a course in drawing, and is administered in connection with the class-room and lecture work in Descriptive Geometry.

The first topic considered is isometric drawing and cavalier projection, taking up the matter of isometric axes, planes and lines, isometric scales, the practical application of the system and method of procedure, illustrated by examples. Further on, solids, screw-threads, their exact and conventional representation, and the matter of distortion are considered. Shadow and shadow construction, theory of right line, one and two plane shadows, curved line and shadows of solids are treated in the second chapter. Perspective is next taken up, including mechanical and free-hand perspective, parallel and angular perspective and how to assume conditions, and the perspective of shadows. Two chapters are devoted to exercises for the student, theoretical as well as practical problems being discussed. The practical problems seem to be especially well chosen.

The text matter is brief and well arranged. The illustrations, as a whole, well represent the different subjects chosen, although some are at times incorrectly executed and seem to suffer from defects inherent to the wax-process of engraving.

HYDRAULIC DIAGRAMS.—For the Discharge of Conduits and Canals. Based upon the Formula of Ganguillet and Kutter. By Charles H. Swan, M. Am. Soc. C. E., and Theodore Horton, M. Am. Soc. C. E., with a Description of the Diagrams and their Use by Theodore Horton. Second edition. New York: The Engineering News Publishing Co. Cloth; 5¾ x 9¼ ins.; pp. 45. $1.

The favorable reception accorded this book has necessitated a further printing. This, in turn, has afforded an opportunity to add a new plate and to italicize certain phrases in the text for emphasis and ease of reference. The new plate gives discharges and velocities for small conduits on a larger scale than they were formerly shown. The diagrams, as a whole, serve for closed conduits of eight different types of cross sections, and also for canals of both rectangular and trapezoidal section.

HIGH TENSION POWER TRANSMISSION.—A Series of Papers and Discussions Presented at the Meetings of the American Institute of Electrical Engineers, under the auspices of the Committee on High-Tension Transmission (Ralph D. Mershon, Chairman). New York: McGraw Publishing Co. Cloth; 6 x 9½ ins.; pp. 466; illustrated. $3.

This volume is a collection of reprints from the Transactions of the American Institute of Electrical Engineers, covering the papers and discussions which were brought out by that society's committee on High-Tension Transmission during 1903 and 1904. The papers and discussions appear in just the form in which they were published in the Transactions, but an index of subjects and authors has been added.

Bridge Design and Construction.

Reviewed by Leon S. Moisseiff,* Assoc. Mem. Am. Soc. C. E.

THE DESIGN AND CONSTRUCTION OF METALLIC BRIDGES.—By William H. Burr, M. Am., Soc. C. E., M. Inst. C. E., Professor of Civil Engineering in Columbia University, and Myron S. Falk, Ph. D., Assoc. M. Am. Soc. C. E., Lecturer in Civil Engineering in Columbia University. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6x9 ins.; pp. 532; 192 figures in the text and four folding plates. $5.

The design and construction of steel bridges in America has shown during the last decade a steady and uninterrupted advance in the quality of scientific work done, as well as in its quantity. The increased number of technically educated engineers has widely spread the rational application of the principles of mechanics and the empiric data of the structural materials. To the effects of vertical loads and lateral wind other causes of minor importance also began to be taken into consideration; to the established methods of determining the stresses due to the external causes new ones were added, facilitating one or the other phase of the computer's work; finally, the increased knowledge of the materials used, and the accumulated observation on structures in service, brought about a better understanding of the behavior of the various members and their detail connections. Simultaneously with the advance in designing and detailing metallic bridges grew also the demands made on them in sustaining heavier loads and in increased stiffness.

The advance in the art of bridge building is, as would be expected, reflected in Messrs. Burr and Falk's book on "The Design and Construction of Metallic Bridges." The engineers who were familiar with Professor Burr's standard work, "The Stresses in Bridge and Roof Trusses, Arched Ribs and Suspension Bridges," will readily recognize the old book in the new garb, but they will also see at a glance that new material has been added and that much of the old has been rewritten to correspond with the new requirements and practice.

Professor Burr's book on bridges shared heretofore to some degree the fame of Rankine's works, in that it contained much very valuable matter, which had to be mined out of the rocks. The reviewer heard this view expressed many times during his college years, when this book served as the text book, and in later years in conversation with engineers. It could not be denied that much of this was true, though in the mind of the reviewer the book maintained during all these years its place as the best book on bridges published in English. The chapters on swing bridges and arched ribs especially were of the best then offered. The new book appears to have been made much plainer, and many missing links have been supplied. The chapters on arched ribs, suspension bridges and cantilevers have been omitted in this book, and "together with certain statically indeterminate forms will be treated in a supplementary volume." Other chapters have been added.

The book consists of ten chapters, the first of which is "A Historical Sketch of Bridge Building." The history of the evolution of any art or science is always a useful and interesting introduction to the subject itself, and enables the reader to orient himself as to the present stage of the subject treated. But the 37 pages devoted to the history contain an enumeration of facts and present only some of the raw material for a history of the evolution of bridges, and in their present shape are entirely inadequate to furnish any guiding ideas.

Chapter II. is devoted to the general types of trusses, loads and specifications, and contains the most recent practice in railroad and highway bridges. Several typical specifications, representative of modern requirements, are extracted. The various methods practiced in providing for impact stresses are given, but the advantages of using an impact formula are not discussed; a record of modern practice is simply presented without sides being taken by the authors. Traction stresses, stresses due to centrifugal load, wind, temperature, initial tension and snow all get due consideration.

Chapter III. treats of Moments and Shears, and of the Design of Plate Girders. It gives the usual methods of finding the positions of greatest bending and shear, the general formulas of the common theory of flexure, and, finally, devotes some 28 pages to the design of a plate girder. The latter gives an excellent treatment of plate girder design, clear and full of information, and while the subject is comparatively simple, it yet requires all the fundamental principles of good designing.

Chapter IV. and V. treat of all kinds of Trusses with Parallel and Horizontal Chords and with Chords Not Parallel, and covers 133 pages. Some additional explanations excepted, the matter is the same as in the older edition of this book; many numerical examples of trusses and how to find their stresses have, however, been added.

To the chapter on swing bridges has been added the treatment of these bridges by the method of deflections, with examples in each case. A short chapter on the Deflection of Framed Structures and Outline of the Theorem of Least Work has been added. No proof of this principle is given except that "the hypothesis is entirely reasonable." There are several demonstrations of the principle of least work, and one of them should have been given. The subject is treated here too scantily, and both Castigliano and Mueller-Breslau could furnish some simple examples illustrating the advantages of its application in many common cases.

The book concludes with chapters on wind stresses and details of construction. The treatment of wind stresses by Professor Burr in the older editions of this book was known to be very thorough, and it has remained so in the new edition, which has in this respect undergone practically no change. Little has also been added to the discussion of details of construction, which could profitably be much extended. There is always a demand for information on details, if fully discussed in the light of recent knowledge. An index of subjects and of names quoted ends up the work.

Regret may here be expressed that highway bridges have received little consideration. The general arrangement and design of highway or better street bridges certainly deserves special treatment; it is a growing subject and still open to much improvement. Floors for railroad bridges have equally been neglected, yet there has recently been brought out much valuable matter in this line.

The appearance of the book has been improved; the numerous cuts, especially, have been made clear and many new ones have been added. Concluding, it may be stated that the book reflects well the advance in the design of metallic bridges, and is a worthy successor to the old standard which it replaces.

*Park Row Building, New York.

PRACTICAL PLANER KINKS.—For Planer Hands. By Carroll Ashley. New York: Hill Publishing Co. Cloth; 5 x 7¾ ins.; pp. 80; 33 figures, mostly in the text. $1.

The author clearly and correctly names his readers when he says: "This is written for the planer hand by a planer hand," referring to the ironworking planer. He describes many special forms of planer tools and special fittings such as chucks, clamps and stops that are useful or essential in planer work. Much in the way of methods of doing work is also discussed or suggested, with regard to regular as well as to special work. The care of the planer also furnishes a theme for some remarks. All this matter is somewhat heterogeneously put together, and in general the treatment does not go far enough back and does not follow out the momentary theme thoroughly and comprehensively. Many good illustrative drawings, and the small size of the whole book, atone in part for these faults. Two remarks of the author merit quoting, as giving purpose to the book and throwing light on the conditions of planer work:

> The planer is probably the most abused machine in the machine shop (p. 5).
>
> A piece well chucked is half planed (p. 41).

The author justly takes occasion to deny the sentiment that "the man who runs a planer has a snap." Planer work is of broad range and requires a first-class workman. To the machinist it is as difficult as designing a planer is to the machine-tool engineer. Proper planer design, by the way, seems to be a science that is as yet more under hats than in books.

THE NATIONAL MUNICIPAL LEAGUE.—Proceedings of the New York Conference for Good City Government and the Eleventh Annual Meeting, held April 25, 26, 27 and 28, 1905, at New York. Clinton Rogers Woodruff, Editor. (Philadelphia, Pa.): The National Municipal League. Cloth; 6 x 8¾ ins.; pp. 404. $1.25.

Municipal progress for the year 1904-5 is here reviewed by the secretary and by several other writers, Mr. Woodruff surveying the whole American field and his colleagues taking up more limited areas. The framework of Canadian municipal government is well described by Dr. W. Bennett Munro, of Harvard University. A number of the papers deal more or less directly with municipal ownership and with municipal corruption through franchise companies. Uniform municipal accounting, instruction in municipal government in the public schools, primary legislation and nominations of municipal officials are each discussed at some length and with ability. The whole volume constitutes a tonic for stimulating interest in good municipal administration.

CENTRAL ELECTRIC LIGHT AND POWER STATIONS. —1902. Special Reports, Bureau of the Census. S. N. D. North, Director. Prepared under the Supervision of William M. Steuart, Chief Statistician for Manufacturers. Text by Thomas Commerford Martin, Expert Special Agent. Washington, D. C.: Pub. Doc. Paper; 9 x 11½ ins.; pp. 175; 98 tables; illustrated.

An abstract of portions of the text of this bulletin was published in our issue of Sept. 28, 1905. In the abstract were some comparative figures of municipal and private plants. The report presents statistics for all stations in use during any part of the year ending June 30, 1902. About eighty pages of text are used to summarize and discuss the text and some twenty pages of text are devoted to the "History and Development of Electric Lighting."

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Engineering and Laboratory Chemistry.

Reviewed by Leonard P. Kinnicutt.*

ENGINEERING CHEMISTRY.—A Manual of Quantitative Chemical Analysis for the Use of Students, Chemists and Engineers. Third Edition. By Thomas B. Stillman, M. Sc., Ph. D., Professor of Analytical Chemistry in the Stevens Institute of Technology. Easton, Pa.: The Chemical Publishing Co. Cloth; 6 × 9 ins.; pp. 597; 139 figures, mostly in the text. $4.50.

SECOND YEAR CHEMISTRY.—A Handbook for Laboratory and Class Work. By Edward Hart, Ph. D., Professor of Chemistry in Lafayette College, Easton, Pa.; The Chemical Publishing Co. Cloth; 5½ × 7 ins.; pp. 165; 31 figures in the text. $1.25.

Engineers have not the time, even if they have the training, to make anything but the simplest quantitative tests, but they should know how various quantitative determinations are made and have such a general knowledge of chemistry as to be able to interpret the results received from the chemist and draw from them the correct conclusions. This is the training that is now being given to engineers in the best scientific schools in our country, and for students who have or are receiving this training Professor Stillman's book will be a valuable addition to their library.

The book is not a manual of quantitative analysis; it is not a book which would be used to teach a young man the principles of that subject, but is a book from which the engineer can obtain information as to the chemistry of those substances which he is most likely to come in contact with in his professional work. It tells him how those substances are analyzed, and how, from the data thus obtained, he can decide as to their value.

The main subjects treated of in the book are Water, Fuels (solid, gaseous and liquid), Iron and Steel (including the management of blast furnaces), Cements, Building Stones, Asphalt, Paper, Alloys, Petroleum and Lubricating Oils. The subjects are well chosen, and the author has treated them in a very comprehensive way, not at all contenting himself with merely describing the methods used in the analysis of the various substances, but giving that information regarding the various substances which would enable an inquirer to decide in a given case what determinations should be made to give him the information he desires and further how to make use of the information thus obtained. As an example of this, under the subject of fuels, pages 104 to 206, not only are the methods used in determining the calorific power of solid and gaseous fuels, both from the data obtained from analyses and from the results obtained by the calorimeter, given, but also how these data are employed in determining the efficiency of a boiler plant. Not only are the methods of gas analysis described, but also a description of the manufacture of coal water and gas, and the composition of coal and water gases, are also given. Under water analyses, pages 43 to 105, one finds not only the methods for the technical and sanitary analyses of water, but also the effect of different waters on boilers, how those effects can be modified by feed water heaters or by chemicals, how water can be softened, and how purified by slow sand and by mechanical filtration. Similarly are treated the other subjects mentioned, and numerous references to original researches are given throughout the book.

The book, like all books, can be criticized in some respects: the most serious fault to be found with it is the omission of specific directions as to sampling. The most important part of a technical analysis, one which is vital if results of any value are to be ensured, is the obtaining of a correct sample of the substance to be analyzed, and this is certainly a subject about which the engineer should have detailed information. The whole value of a boiler plant test, for example, depends on a correct sample of the coal used being obtained, and in a book intended for engineers it would certainly seem as though the method of sampling adopted by the Committee on Coal Analysis of the American Chemical Society should be given in substance if not detail. The same, of course, is true regarding iron ores, water or other substance. The first thing for an engineer to know is how to obtain a fair and correct sample, for otherwise the analysis that is made will be valueless.

It could also be said that the book in certain cases fails to give sufficient information regarding the interpretation of the results of chemical analyses. This is particularly noticeable in respect to the sanitary analysis of water.

The book, as a whole, however, is a book well worth having written and certainly one that will frequently be consulted by engineers.

The first part of Professor Hart's book is devoted to the consideration of some of the fundamental, theoretical principles of chemistry. This is followed by a description of the chemical balance, the method of weighing and testing of weights, and a few problems in quantitative analysis. The main portion of the book, pages 57 to 138, is a manual on qualitative analysis, succeeded by a chapter on the preparation of samples for quantitative analysis, and a few more examples in quantitative work.

The book is interesting as showing the method used by Professor Hart with his classes at Lafayette College, and undoubtedly, in his hands, accomplishes the desired result. It contains much that should be included in the work of second year students in chemistry, but the arrangement of the work is one that seemingly would not usually produce the best results.

The idea of Professor Hart in prefacing the qualitative work with a few problems in quantitative is that it teaches the beginner the necessity of extreme care, and that all his subsequent work will be thereby improved. The reviewer doubts whether neatness and care can be better taught by a few quantitative exercises than by the methods of qualitative analysis. Neatness and care in laboratory work depend upon the instructor and not upon the subject taught.

*Director Department of Chemistry, Worcester Polytechnic Institute, Worcester, Mass.

PROCEEDINGS OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.—Chicago: L. C. Fritch, Secretary. Paper; 6 × 9 ins.; pp. 872; illustrated. Paper, $2; cloth, $2.50; half morocco, $3.

The greater part of this volume consists of reports, discussions and general proceedings of the sixth annual convention, held at Chicago in March, 1905. Financial reports and lists of officers, committees, members, and railways represented, cover about 100 pages. The report of the Committee on Iron and Steel Structures is one of the most important, and (with the discussion and a number of illustrations and tables of tests of riveted joints) covers some 290 pages; it comprises a historical sketch of the development of American bridge specifications, a study of [illegible] and engine weights used in designing bridges, a description of a series of tests of riveted joints and punching and reaming tests, and a form of general specifications for steel railway bridges. The other principal reports are those of the committees on wooden bridges and trestles; roadway; signaling and interlocking; yards and terminals; water service; records, reports and accounts; buildings; masonry; ballasting; ties. There is also an interesting discussion on rails, which brings out very strongly the unsatisfactory quality of metal in modern steel rails.

STATE BOARD OF HEALTH OF MASSACHUSETTS. Thirty-Sixth Annual Report. Boston, Mass.: Pub. Doc. Cloth; 5¾ × 9 ins.; pp. xxxvi. + 448.

In its main divisions this report is along the usual lines: Advice to cities and towns on water supply and sewerage questions, analyses of the public water supplies of the State, waterworks and rainfall statistics, reviews of water and sewage purification experiments at Lawrence, and reports on food and drug analyses, typhoid fever, malaria and like subjects; also statistical summaries of disease and mortality. The water supply analyses for some years past are averaged and studies of the analyses grouped under surface and ground waters, and sub-grouped under color, odor and various chemical constituents are given. Special studies in sewage purification reported on relate to nitrogen storage and disposal in sand filters, contact beds and sprinkling filters; various sewage bacteria and their relations to sewage purification; a new turbidity standard; sprinkling filters and septic tanks. In water purification, the use of both copper sulphate and aluminum sulphate in connection with sand guarantee that this book will not be found want- filtration was studied, and also double sand filtration.

A WINTER VISIT TO SOME SEWAGE DISPOSAL PLANTS IN OHIO, WISCONSIN AND ILLINOIS.—By C.-E. A. Winslow (Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology, Boston, Mass.) Reprinted from Journal of the Association of Engineering Societies, Vol. XXXIV, No. 6. Paper; 6 × 9 ins.; pp. 335 to 361; 10 illustrations.

It would be advantageous to all concerned if more such "visits," whether winter or summer, were made and reported. The paper describes briefly a number of sewage works, giving most attention to such important points as the present working condition of the plants and the lessons to be drawn from their success and their failures.

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How Far Should Government Regulation of Railway Rates Extend?

RESTRICTIVE RAILWAY LEGISLATION.—By Henry S. Haines, M. Am. Soc. C. E., M. Am. Soc. M. E.; Past President American Railway Association, Author of "American Railway Management." New York: The Macmillan Co. London: Macmillan & Co., Ltd. Cloth; 5¼ × 8 ins.; pp. 335. $1.25, net.

GOVERNMENT REGULATION OF RAILWAY RATES.—A Study of the Experience of the United States, Germany, France, Austria-Hungary, Russia and Australia. By Hugo Richard Meyer, Assistant Professor of Political Economy in the University of Chicago. New York: The Macmillan Co. London: Macmillan & Co., Ltd. Cloth; 5½ × 8 ins.; pp. xxvii + 486; one folding map. $1.50, net.

It is a notable fact that of all the voluminous literature on the relations of the railways and the public, very little has been written by railway operating officers. A great deal has been put forth on the railway's side by the paid attorneys of the railways and by others, who, professing to write as independent students of the problem, have actually been subsidized to defend the railway position. Then there are the works, many of them admirable, of professors and students of economics, who have treated the subject from a broad point of view.

The value and importance of Col. Haines's book are largely due to the position of the author and his intimate acquaintance with railway operation as an official in direct charge for many years. As many of our readers will recall, Col. Haines was for many years Vice-President and General Manager of the Plant system of railway and steamship lines. He has served as Commissioner of the Southern Freight Association and he has held the highest office that it is in the power of American railway companies to bestow on any one, that of President of the American Railway Association.

Such a man might naturally be expected to follow the current of opinion among railway officials generally and oppose all legislative interference with railway affairs.

It is greatly to Col. Haines's credit that he has adopted a much broader view. He accepts without question the necessity of state or national supervision of railway operations. He points out that the days of competition in the railway business are practically over; that with the whole railway network under what is practically one control, competition will be no longer present to insure the public low rates and good service and hence supervision and control by some public authority is inevitable.

That such public control has its dangers, past experience has abundantly shown; and there are many who, because of past blunders and errors, decry all attempt at state supervision. From a broader outlook, however, it is perceived that with all its imperfections, restrictive railway legislation in the past has on the whole produced beneficial results; and that it would be as foolish to abandon all further attempts at state regulation because of past blunders, as it would be to jump to the extreme of government ownership because of the mismanagement and financial corruption of which our railway history under private ownership has been full.

There are a few special features of Col. Haines's discussion which we may take space to note. He shows, for example, that a large part of the discrimination in railway rates concerning which complaint is made, is not discrimination between persons—which everybody admits to be wholly evil—but between places. It is not a question of excessive rates per se charged by the railways but of rates which are higher than those charged to some other town. It is the competition of New York with its rival Atlantic ports, and with the ports of the Gulf; the competition of Chicago with Kansas City; of the minor centers of wholesale trade with the large cities. We can all see the danger of leaving the adjustment of these conflicting interests to railway traffic managers; but other dangers will come in when public authorities have to pass on these questions. No more difficult and delicate task confronts our Federal Government than the task of acting in cases where the conflicting interests of different sections of the country must be adjusted.

Col. Haines, we need hardly say, is fair to the railways. He is practically familiar with the railway question and with what may be called the pro-railway arguments that have been rehearsed in the public press till they are threadbare. It means a great deal for such a man to present so cogent and unanswerable an argument for public supervision as the following:

> Much of the profit derived from the construction or consolidation or reorganization of the railroad system of this country was legitimately the fruit of hard labor, physical and mental, the reward of prudent business methods or of intelligent foresight; but, after making a liberal allowance with compound interest for the investment in that railroad system of the savings of the humble and the capital attracted from foreign lands, the residuum which represents the investments from public funds raised by taxation and of grants from the public domain is certainly large enough to entitle the citizens of the United States to a voice in the management of the lines of transportation which have been built over their private estates by the exercise of their own sovereign power—roads constructed largely from the taxation of their own property and income, a system of transportation that has rendered competition impossible over the public highways by common carriers. The interest thus acquired by the citizens of this country in the national railroad system is as legitimate an investment as that now possessed by syndicates, and is as much entitled to representation of some character.

Perhaps the most interesting portion of Col. Haines's book, and a unique and valuable record to the student, is the historical matter which it contains. The story of early rate-making, of the early and later passenger wars, and freight wars, of the granger agitation and legislation, has nowhere been better told, and told by no one in a better position to know authoritatively that of which he writes.

Turning now to Prof. Meyer's book we find it the strongest possible contrast to Col. Haines's. Prof. Meyer, in his preface, declares that he "has become firmly convinced of the unwisdom of government regulation of railways or their rates"; and he has hurried into print with this book lest Congress "may be led to enact ill-considered laws granting dangerously enlarged powers to the Interstate Commerce Commission."

Part I. of the book describes Prof. Meyer's studies of the state-owned and operated railways of Europe and Australia, and it is to be particularly noted that the Professor in his zeal to prove his case appears to make no distinction between Government supervision and regulation and absolute Government ownership and operation. In Part II. Prof. Meyer takes up conditions in the United States and retells the oft-told story of how the railways have built up the great West. A large part of this section of the book is devoted to criticism of the Interstate Commerce Commission's decisions. Prof. Meyer's thesis is that the railways are better able to make rates than any public commission or court, and so far as we have found, he would leave the railway companies absolutely free to charge the shipper and traveler such rates as they choose. In the concluding paragraph of his book, however, he does go so far as to say that "it is impossible for the State to conserve and promote the public welfare by intervening in the regulation of railway rates *beyond the point of seeking to abolish secret personal discriminations, guaranteeing that all rates shall be reasonable per se and providing that those rates which involve the question of relative reasonableness shall embody compromises which were made in intelligence and good faith.*

The italics are ours; and we fear Prof. Meyer will have to write another book to explain how the State can protect the public in these ways, which he is compelled to admit to be essential, without some such legislation as that which President Roosevelt has proposed for increasing the powers of the Interstate Commerce Commission.

We sincerely recommend to Prof. Meyer a study of Col. Haines's book. He will there find set forth some of the evils of the system of private railway management, which may match some of the evils of state railway control which Prof. Meyer has so well set forth.

It is not because Government supervision of railways, or banks, or insurance companies, or municipal public utilities, or any form of commerce and industry is expected to be ideally perfect, that some of the ablest men in public life are favoring the extension of Government supervision. It is because the evils of the present day private control of great monopolies have become so vast and have resulted in so vast a corruption of the Government itself that a change is demanded.

THE TENSILE STRENGTH OF COPPER-TIN ALLOYS.—By E. S. Shepherd and G. B. Upton. Reprinted from the "Journal of Physical Chemistry" of June, 1905. Cornell University, Ithaca, N. Y.: The Authors. Paper; 7 × 10½ ins.; pp. 476; 7 line-cuts; 3 tables.

Work important to the engineer, to the metallurgist or the metallographist, and to the physicist and chemist, is reported here. The work was done under a research grant of the Carnegie Institution to Prof. W. D. Bancroft, of Cornell University. A freezing-point diagram for copper-tin alloys, and a tensile strength diagram, both of them differing materially from earlier representations of the facts, form central features of the results.

COMPARATIVE STATISTICS, CITIES OF OHIO 1904.—Department of Auditor of State, Bureau of Inspection and Supervision of Public Offices. Columbus, O.: Pub. Doc. Paper; 6½ × 9½ ins.; pp. 160; tables.

Ohio has the honor of being a pioneer State in establishing a State bureau of uniform municipal accounting, with State audit, returns to the bureau from each city and the compilation and publication of an annual volume of comparative municipal statistics. The Legislative act providing for all this, as amended in April, 1904, is printed in the volume before us. The statistics here given are compiled from returns for the year 1904, made by the several auditors of the 71 cities of the State: cities in Ohio, under the new municipal code, including all municipalities of 5,000 population and over. The statistical tables include consolidated financial statements, ordinary and extraordinary receipts and expenditures, salaries, wages, tax duplicates and tax rates, and miles of paved streets and of sewers. These reports promise to be of great value, both in and out of Ohio.

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The Automatic Regulation of Turbines.

Reviewed by Storm Bull.*

DIE AUTOMATISCHE REGULIERUNG DER TURBINEN.—By Dr.-Ing. Walther Bauersfeld, Assistant in the Royal Technical High School at Berlin. Berlin, Germany: Julius Springer. Paper; 5¾ x 8¾ ins.; pp. 208; 126 figures, mostly in the text. 6 marks; American price, $2.40.

The subject of the regulation of the various kinds of prime movers has not received an adequate treatment in the technical literature of to-day, with the exception of Tolle's book on the subject, which, like the one before us, is published by Springer, of Berlin. The literature in the English language certainly does not contain anything satisfactory except as dealing with problems of the most elementary character. The reason for this state of affairs is probably that the subject is a very difficult one, and that the demands for a close regulation of all kinds of prime movers is of comparatively recent date, so that the men who have been studying the problem have not yet found the time to bring out their theories and results. It is nevertheless a fact that the close regulation has been accomplished, at least to quite a satisfactory extent; and here again, as in so many other instances, the practising engineers have been the leaders, to be followed later by those who put the inventions and ideas of the former into classes and systems and make up the working theory. This is especially true of the regulators for water turbines, for which the governor always must be an indirect one, the governor always being accompanied by a "servo-motor" so-called, which furnishes the energy by means of which the regulating apparatus of the turbine is moved. The water turbine is now nearly one hundred years old, and for the larger part of this time the manufacturers have furnished more or less adequate governors for the same, although, as stated above, it is not till within a comparatively small number of years that the close regulation, which we require to-day, has been accomplished.

Mr. Bauersfeld's book treats, as the title indicates, exclusively of the automatic regulation of turbines. The author states in his preface that his conclusions are equally applicable to all motors in which indirect regulation is required, notably the steam turbines, but any one acquainted with these latter knows that indirect regulation is not used for all the steam turbines made at the present time. The book is an attempt to give a complete classification and theory of the various turbine-governors now made and it is evident that the author is thoroughly acquainted with the practice of to-day, the best examples of American practice, for example, being thoroughly discussed.

Altogether the largest part of the book is taken up with the theory of the subject of regulation. In this the author follows to a great extent the method of Tolle. But it would seem to the reviewer that in order to reach conclusions or formulas which according to the author would be of such nature that they could be used in practise, he has made so many assumptions or approximations that his conclusions will be of doubtful value. It should, however, be remembered that the subject covered by this book is to a great extent an unploughed field, and that it cannot be expected that after such a first "working" the field should be in such good condition as if it had been worked a good many times before. It is certainly a very interesting book and will reach many who will profit by it and carry the investigations farther. To the practising engineer the last fifty pages of the book will be the most interesting. Here he will find excellent illustrations, partly detailed drawings, of the best kinds of governors for water turbines made at the present time, accompanied by satisfactory explanations. At the very end of the book a computation of a governor based on the conclusions reached in the first part of the book is given, and this part of the book should also help to make it more useful to the men in commercial practice.

*Professor of Steam Engineering, University of Wisconsin, Madison, Wis.

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WATER-SUPPLY AND IRRIGATION PAPERS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Docs. Paper; 6 x 9 ins.

No. 123: Geology and Underground Water Conditions of the Jornada del Muerto, New Mexico. By Charles Rollin Keyes. Pp. 42; nine plates and 11 text illustrations.

No. 135: Report of Progress of Stream Measurements for the Calendar Year 1904. Prepared under the Direction of F. H. Newell, by D. W. Ross, J. T. Whistler, and T. A. Noble. Part XII.—Columbia River and Puget Sound Drainage. Pp. 300; two plates and one text illustration.

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No. 140: Field Measurements of the Rate of Movement of Underground Waters. By Charles S. Slichter. Pp. 122; 15 plates and 67 text illustrations.

No. 141: Observations on the Ground Waters of Rio Grande Valley. By Charles S. Slichter. Pp. 83; five plates and 32 text illustrations.

No. 145: Contributions to the Hydrology of Eastern United States, 1905. Myron L. Fuller, Geologist in Charge. Pp. 220; six plates and 42 text illustrations.

No. 152: A Review of the Laws Forbidding Pollution of Inland Waters in the United States. Second Edition. By Edwin B. Goodell. Pp. 149.

The rapidity with which these Papers are being issued and reissued and the similarity of certain of them in general plan makes any notice of many of them unnecessary and lengthy comment on most of them impracticable. Of Professor Slichter's two Papers, listed just above, it may be said that No. 140 is an amplification of an earlier one (No. 67) on the same subject, and is a practical monograph which may well be eagerly sought by anyone to whom the subject appeals. No. 141, including both underflow tests and tests of numerous pumping plants, is also an eminently practical Paper.

Paper 145 contains 20 sections by 14 geologists, edited and in part written by Mr. M. L. Fuller, Chief of the Eastern Section, Division of Hydrology. It is the third of a series of progress reports on the subject indicated. The papers are grouped under five heads: (1) special artesian problems; (2) water resources of certain areas; (3) descriptions of special localities; (4) water supplies of special types of deposits; (5) descriptions of important springs. Most of the 20 contributions are chiefly of local interest. The sections of most general interest are: "Drainage of Ponds into Drilled Wells," by Robt. E. Horton, the object here being land reclamation. "Construction of the So-Called Fountain and Geyser Springs," and "A Convenient Gage for Determining Low Artesian Heads," both by Mr. Fuller. The last-named paper is condensed from an article by Mr. Fuller entitled "Measurement of Low Artesian Heads," published in Engineering News for June 8, 1905.

In Paper 152 Mr. Goodell brings down to 1905 his summary and discussion of the common law and the statutes of the various States on the important subject of water pollution.

THE ROAD-BUILDERS.—By Samuel Merwin. With Illustrations by F. B. Masters. New York: The Macmillan Co. London: Macmillan & Co., Ltd. Cloth; 5 x 7¾ ins.; pp. 313. $1.50.

To those who know or wish to know about railway construction in the arid West, under the stress of competition with a rival line, this story will be interesting. The character of Paul Carhart, the resolute and successful engineer of construction, is particularly well drawn. There is no lack of well contrived incident and on the whole the book is true to life.

REPORT OF THE NEW YORK BAY POLLUTION COMMISSION.—To Hon. Frank Wayland Higgins, Governor. March 31, 1905. Louis L. Tribus, Secretary (84 Warren St., New York City). Albany, N. Y.: Pub. Doc. Paper; 5¾ x 9 ins.; pp. 135; folding map.

A lengthy abstract of the body of this report and a list of the appendixes, accompanied by editorial comment, was printed in Engineering News for May 4, 1905. The main conclusions were against the discharge into the Bay of untreated sewage from the proposed Passaic Valley trunk sewer and the formation of a New York-New Jersey Metropolitan District Sewerage Commission to report on ocean disposal for the district.

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Single Wire Independent Telegraph Circuits.

Reviewed by Wm. Maver, Jr.*

SYNCHRONOUS AND OTHER MULTIPLE TELEGRAPHS.—Some Methods of Obtaining Independent Telegraph Circuits on a Single Wire both with and without Synchronism. By Albert Cushing Crehore, Ph. D., M. Am. Inst. E. E., Author of "Alternating Currents" (with F. Bedell). New York: McGraw Publishing Co. Cloth; 6 x 9¼ ins.; pp. 124; 42 figures in the text. $2.

This appears to be somewhat out of the ordinary run of technical books. Its broad title might readily lead to the inference that it is a work relating to the general subject of synchronous and other multiple telegraph systems, but the subtitle is more qualifying and limits the book to a discussion of "some methods of obtaining independent telegraph circuits on a single wire both with and without synchronism." The methods referred to are presumably due to the author.

The multiple telegraph systems other than synchronous systems discussed in the book are modifications of the Edison Phonoplex, the Varley and other somewhat similar systems; sometimes termed superimposed systems. Systems of this kind have been fairly well tried out in practice, and their use appears to be on the wane, not altogether because of inherent technical or economical defects in the systems, but rather because other methods of communication are gradually supplanting them. The author states that his system of this kind was installed on a railroad telegraph line several years ago, but he omits to state with what degree of success this circuit has been operated or whether it is at present in operation.

The first part of the book is taken up with a description and discussion of instances of the type of telegraph systems just mentioned. The second and third parts of the book relate to methods of obtaining synchronism at distant points; and to synchronous telegraphs, respectively. The subject matter of the second and third part of the book consists generally of a description of the laboratory experiments of the author with synchronous telegraphy and the apparatus therefor.

In the preface the author states that the results of the experiments referred to worked out in detail in the laboratory on artificial lines have afterwards been applied to real wires with almost identical results. Unfortunately, however, the text gives no clue to the actual lines on which the author's synchronous systems (if he refers to the results of actual practice) have been employed; nor, if employed in actual line service, does he give any intimation as to the quality of the service rendered. This is the more to be regretted, perhaps, inasmuch as synchronous telegraph systems that have worked beautifully in a laboratory have been known to fail dismally under actual line tests.

The author himself does not appear to be certain that synchronous telegraph systems will come into general operation. He says (page 46): "If synchronous telegraphs ever come into more general use, it is difficult to say how the problem of obtaining synchronism will be solved, etc."

The book contains some very interesting information on the well known "tailing" action of electric currents in rapid telegraphy, whereby the current is felt on receiving circuits connected with segments not in synchronism with the transmitting segments. These effects were already well known to workers in synchronous telegraphy, but the author has taken pains to show by laboratory experiments the conditions under which this tailing effect becomes harmful, and he indicates certain means whereby possibly it may be diminished, if not eliminated. The author also points out how by suitable arrangements of the segments of the rotating disks or cylinders usually employed in synchronous telegraphs, it may be practicable to send messages in opposite directions on one wire.

The author's purpose in writing this book is not stated, and the text does not make it entirely clear. It is, however, to be presumed that the arrangements or systems shown in the book are protected by letters patent and it is conceivable that the author takes this means of obtaining a hearing before the technical public.

*Electrical Engineer, 136 Liberty St., New York City.

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Publications Received.

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THE CITY.—The Hope of Democracy. By Frederic C. Howe, Ph. D., Author of "Taxation and Taxes in the United States under the Internal Revenue System." New York: Charles Scribner's Sons. Cloth; 5½ x 8¼ ins.; pp. 319. $1.50, net.

DISPOSITION OF MUNICIPAL REFUSE.—American Conditions Illustrated by Data from Representative Cities. By Col. W. F. Morse, Sanitary Engineer (25 Broad St., New York City). Reprinted from the October, 1905, issue of the "Municipal Journal and Engineer." Paper; 9¼ x 12 ins.; pp. 169 to 173.

EARTHWORK TABLES.—By R. S. Henderson. Part I. Preliminary Earthwork Tables, Giving Cubic Yards per 100 Feet for Level Sections, to which is added a Graphical Method of Estimating Quantities from a Profile. Part II. Earthwork Tables, Giving the Volume in Cubic Yards of Prismoids 100 Feet Long by the Average End Area Method. New York: The Engineering News Publishing Co. Stiff paper; 12¼ x 9¼ ins.; pp. 32. $1.

ELEMENTS OF DESCRIPTIVE GEOMETRY.—With Applications to Isometric Projection and Other Forms of One-Place Projection. A Text-Book for Colleges and Engineering Schools. By O. E. Randall, Ph. D., Professor of Mechanical Drawing, Brown University. Boston and New York: Ginn & Co. Cloth; 6¼ x 9¼ ins.; pp. 209; 193 figures in the text. $1.50.

FOWLER'S ELECTRICAL ENGINEER'S YEAR BOOK AND DIRECTORY OF LIGHT, POWER AND TRACTION STATIONS.—1906. Manchester, Eng.: Scientific Publishing Co. Leatherette; 4 x 6¼ ins.; pp. 643; illustrated. Post free, 1¾ shillings; American price, 70 cts.

FOWLER'S MECHANICAL ENGINEER'S POCKET BOOK, 1906.—Edited by William H. Fowler, Wh. Sc., M. Inst. C. E., M. I. Mech. E., M. Iron and Steel Inst. Manchester, Eng.: Scientific Publishing Co. Leatherette; 4 x 6¼ ins.; pp. 516; illustrated. Post free, 1¾ shillings; American price, 70 cts.

TWO GROWTHS OF CHLAMYDOMONAS IN CONNECTICUT.—By Frederick S. Hollis (New Haven, Conn.). Reprinted from Transactions of the Amer. Micro. Soc., Vol. XXIV., 1903. Paper; 6¼ x 9¾ ins.; pp. 13 to 16.

HANDBOOK OF METALLURGY.—By Dr. Carl Schnabel, Konigl. Preuss. Ober-Bergrath Professor of Metallurgy. Translated by Henry Louis, M. A., A. R. S. M., F. I. C., etc., Professor of Mining at Armstrong College, Newcastle-upon-Tyne. Second Edition. Vol. I. Copper—Lead—Silver—Gold. London: Macmillan & Co., Ltd. New York: The Macmillan Co. Cloth; 6 x 9 ins.; pp. 1,123; 715 figures in the text. $6.50.

IMMUNITY IN INFECTIVE DISEASES.—By Elie Metchnikoff, Foreign Member of the Royal Society of London, Professor at the Pasteur Institute, Paris. Translated from the French by Francis G. Binnie, of the Pathological Department, University of Cambridge. Cambridge, Eng.: The University Press. New York: The Macmillan Co. Cloth; 6¼ x 9¾ ins.; pp. 591; 45 figures in the text. 18s., net; American price, $5.25, net.

MODERN LOCOMOTIVE ENGINEERING.—With Questions and Answers. A Plain, Practical Treatise on the Construction, Care and Management of Modern Locomotives. By Calvin F. Swingle, M. E., Author of the 20th Century Hand Book for Steam Engineers and Electricians; Steam Boilers, their Construction, Care and Management, etc., etc. Chicago, Ill.: Frederick J. Drake & Co. Leather; 4¾ x 6¾ ins.; pp. 630; folding and other plates, and many text illustrations. $3.

OFFICE OF EXPERIMENT STATIONS.—(A. C. True, Director). Annual Report for the Year Ended June 30, 1904. Washington, D. C.: Pub. Doc. Cloth; 6 x 9½ ins.; pp. 724; 42 plates and 11 text illustrations.

PHYSICS.—By Charles Riborg Mann, The University of Chicago, and George Ransom Twiss, The Central High School, Cleveland. Chicago: Scott, Foresman & Co. Cloth; 5¼ x 8 ins.; pp. 453; eight plates and 237 text illustrations. $1.25.

PROCEEDINGS OF THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—Edited by The Publication and Library Committee. W. H. Roberts, Editor and Business Manager. New York: The Society. Cloth; 6 x 9¼ ins.; pp. 211; 38 plates and six text figures.

THE PRODUCTION OF PETROLEUM IN 1904.—By F. H. Oliphant. Extract from Mineral Resources of the United States, Calendar Year 1904: David T. Day, Chief of Division of Mining and Mineral Resources. Washington, D. C.: Pub. Doc. Paper; 6 x 9 ins.; pp. 312; one plate.

RADIO-ACTIVITY.—By E. Rutherford, D. Sc., F. R. S., F. R. S. C., Macdonald Professor of Physics, McGill University, Montreal. Second Edition. Cambridge, Eng.: The University Press. New York: The Macmillan Co. Cloth; 5½ x 8¾ ins.; pp. 580; 108 figures, mostly in the text. 12s. 6d., net; American price, $3.50, net.

THE SANITARY PROTECTION OF WATER SUPPLIES.—By Kenneth Allen, Chief Engineer Water Department, Atlantic City, N. J. (Reprinted from Journal Franklin Institute, October, 1905). Paper; 6 x 9 ins.; pp. 297 to 323.

THEORY OF STRUCTURES AND STRENGTH OF MATERIALS.—By Henry T. Bovey, M. A., LL. D., D. C. L., F. R. S., M. Inst. C. E., Professor of Civil Engineering and Applied Mechanics, McGill University, Montreal. Fourth Edition, rewritten and enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9¼ ins.; pp. 968; 943 figures in the text. $7.50, net.

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THE TRANSMISSION OF HEAT THROUGH COLD-STORAGE INSULATION.—Formulas, Principles and Data Relating to Insulation of Every Kind. A Manual for Refrigerating Engineers. By Charles P. Paulding, M. E. New York: D. Van Nostrand Co. Cloth; 5¼ x 8 ins.; pp. 41; 10 tables and seven figures in the text. $1, net.

ZUR THEORIE DER ZENTRIFUGALPUMPEN.—By Dr. Egon R. v. Grünebaum. Berlin: Julius Springer. Paper; 5½ x 8¾ ins.; pp. 119; three plates and 89 text figures. 3 marks; American price, $1.20.

Literary Magazines.

Two interesting studies of the labor problem first attract our attention in the November magazines. The first, in the "Journal of Political Economy," a quarterly published by the University of Chicago, relates to the Chicago teamsters' strike of last spring. The author states that that strike was actually declared and carried out by the labor leaders for personal gain. He goes further and declares that present day labor unionism is permeated through and through with graft. That the labor union exists not to benefit labor as a whole but the members of a little band who would shut out by force all other workmen from doing the work in which they are engaged. That the labor leader holds office not to represent the interests of his union as a whole, but 'to work for his own pocket all the time." In "Scribner's" M. J. Lawrence Laughlin writes on "The Hope for Labor Unions." He urges that unions, by fixing the qualifications for admission on a plane of high labor efficiency may actually control the market in their particular trade, so that employers will prefer to pay union wages and employ union labor, because of its greater efficiency. Some great and strong unions have in fact carried this principle into practice and owe to it much of their success.

In the "Century" for November Mr. Wm. Barclay Parsons writes on "The Panama Canal." It is, of course, a paper written for the popular reader, but an excellent summary of the past history and present status of the enterprise is given. An article on Panama written in a very different vein is found in the November "World's Work." It is entitled "Real Conditions at Panama," and its author, Mr. Eugene P. Lyle, Jr., describes some of the things on the Isthmus that have given rise to criticism and complaint. He writes of conditions that existed in August last and explicitly states that with the advent of the new Chief Engineer, Mr. Stevens, order is being brought out of chaos and a new spirit is animating the whole working force. The labor question is still to be solved, and is confessedly a most difficult one. We commend Mr. Lyle's article to any engineer who is interested to learn what work and life at Panama has been like during the present year. We do not say is now or will be in the future, for Mr. Shonts' statement in this issue shows that an organization is being effected at Panama which will enable the great work to be carried out in an efficient manner.

Two other "World's Work" papers of engineering interest relate to railway construction. One describes the work in progress on the Denver, Northwestern & Pacific, better known, perhaps, as the "Moffat" road. The other tells how Korea was opened to civilization by the railway.

In the "Atlantic" for November Mr. F. W. Coburn writes on "Telephone Development in the United States," and shows how enormously the use of the telephone has increased during the past decade. In New York City, for example, there were only 10,000 subscribers a decade ago, and on Oct. 1, 1904, the number had grown to 136,391 in Manhattan and the Bronx. Mr. Coburn shows in an admirably clear manner that the telephone business is a natural monopoly and that the so-called "independent" telephone movement is economically unsound. He does not go on, however, as he might have done, to show that Government supervision and regulation of the telephone rates will be a necessary accompaniment of the monopoly establishment.

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